This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

LIBRARY STANFORD
417 7810

LANE

MEDICAL LIBRARY

LEVI COOPER LANE FUND

ELEVENTH ANNUAL REPORT

OF THE

LOCAL GOVERNMENT BOARD,

1881–82.

SUPPLEMENT

CONTAINING

REPORT OF THE MEDICAL OFFICER

For 1881.

Presented to both Houses of Parliament by Command of Her Majesty.

LONDON:

PRINTED BY GEORGE E. B. EYRE AND WILLIAM SPOTTISWOODE,

PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.

FOR HER MAJESTY'S STATIONERY OFFICE.

1882.

[C. 3337.-I.] *Price* 6*s*.

ELEVENTH ANNUAL REPORT

OF

THE LOCAL GOVERNMENT BOARD

1881–82.

SUPPLEMENT

CONTAINING THE

REPORT OF THE MEDICAL OFFICER

For 1881.

Presented to both Houses of Parliament by Command of Her Majesty.

LONDON:
PRINTED BY GEORGE E. B. EYRE AND WILLIAM SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.
FOR HER MAJESTY'S STATIONERY OFFICE.

1882.

[C.—3337.-I.] *Price* 6*s*.

LANE LIBRARY

PUBLIC HEALTH.

ANNUAL REPORT

OF THE

MEDICAL OFFICER

OF

THE LOCAL GOVERNMENT BOARD

FOR THE YEAR

1881.

H 2199. Wt. 380. A 2

CONTENTS.

Page

MEDICAL OFFICER'S REPORT:

I.—Vaccination - - - - - - iii.

II.—Animal Vaccination - - - - - - iv.

III.—Small-pox in London in 1881:

Relative incidence on Children less than formerly - vi.
Public and private Vaccination compared - - vii.
Saving of life the result of Vaccination - - ix.

IV.—Inquiries as to Local Prevalences of Disease:

Nature and Causes of Epidemic Diarrhœa - - x.
Case of "Sausage Poisoning" near Chester - - xi.
Scarlatina; Halifax and Durham - - - xi.
Enteric Fever; Blackburn and Melton Mowbray - xii.
Small-pox at Bourne Bridge - - - - xiii.
Infectious Disease among Rag-sorters - - - xiii.

V.—Various Administrative Proceedings - - - xiii.

VI.—Auxiliary Scientific Investigations:

Chemical Analysis of Potable Waters - - - xvii.
Mutations of Micro-organisms: Anthrax Cultivations - xxi.
Other investigations - - - - - xxii.

Appendix A.:

No. 1.—Digest of the Vaccination Officers' Returns for 1879 1

No. 2.—List of the Unions inspected in 1881 as to Vaccination, and an account of the Awards made to Public Vaccinators - - - - 18

No. 3.—Statistics of the National Vaccine Establishment and the Educational Vaccination Stations - - 23

No. 4.—Abstract of the Medical Inspections made in 1881 with regard generally to the incidence of Disease in particular places, and to consequent questions concerning the Local Sanitary Administration - 26

No. 5.—Report by Dr. R. Cory on the early operations of the Animal Vaccine Establishment - - 34

No. 6.—Memorandum issued by the National Vaccine Establishment with supplies of Calf-lymph - - 39

No. 7.—Extracts from a Memorandum by the Medical Officer on the prevalence of Small-pox in London among vaccinated and unvaccinated persons respectively - - - - - 40

No. 8.—Memorandum by Dr. H. Stevens on Small-pox in London in 1881, with special reference to its relation to Public Vaccination - - - 45

APPENDIX A.—*continued.*

Page

No. 9.—Report by Dr. Ballard on a case of "Sausage Poisoning," which occurred at Arlford, near Chester - - - - - - - 57

No. 10.—Report by Dr. Ballard on an epidemic of Scarlatina in Halifax - - - - - - 60

No. 11.—Extracts from a Report by Mr. J. Spear on a prevalence of Scarlatina in the Durham Registration District - - - - - - - 70

No. 12.—Report by Dr. Airy on an outbreak of Enteric Fever at Blackburn - - - - - - 74

No. 13.—Report by Dr. Blaxall on an epidemic of Enteric Fever at Melton Mowbray - - - - 91

No. 14.—Report by Dr. Airy on an outbreak of Small-pox at Bourne Bridge in the Ongar Union (Essex) - 100

No. 15.—Report by Dr. Parsons on an outbreak of Small-pox among Rag-sorters, and on precautions against the spread of infection by rags - - - 106

No. 16.—Memorandum as to Trichinous Disease and cooking of meat - - - - - - - 126

APPENDIX B.:

No. 1.—Report by Dr. R. Cory on the results of Examination of Samples of Water purposely polluted - - 127

No. 2.—Report by Dr. E. Klein on the relation of Pathogenic to Septic Bacteria, as illustrated by Anthrax Cultivations - - - - - - 166

No. 3.—Supplementary Report by Dr. W. S. Greenfield on the Woolsorters' Disease in the Bradford District 207

No. 4.—Report by Mr. Victor Horsley on Septic Bacteria and their Physiological Relations - - - 239

No. 5.—Report by Dr. J. L. W. Thudichum on Further Researches on the Chemical Constitution of the Brain - - - - - - - 287

REPORT.

TO THE RIGHT HONOURABLE JOHN GEORGE DODSON, M.P., PRESIDENT OF THE LOCAL GOVERNMENT BOARD.

SIR,

MEDICAL OFFICER'S REPORT

IN supplement to the Board's Eleventh Annual Report I have the honour to submit to you an account of the proceedings taken in your medical department during the year 1881.

I.—VACCINATION.

Vaccination returns.

The vaccination officers' returns, relating to children whose births were registered in 1879, exhibit a fractional increase in the per-centage of children whose vaccination had not been finally accounted for (Appendix A., No. 1). This may be observed alike in the metropolitan and in the country returns; and it is principally to be ascribed to the diminished care that people have for this protective measure during a year when small-pox is almost wholly absent. For in 1879 there were but 536 deaths from small-pox in the whole of England and Wales against a yearly average of 2,336 in the previous six years.

Inspection.

During 1881 supervision of public vaccination by the medical inspectors of the Board has extended into 278 unions, comprising 1,289 vaccination districts. To 63 per cent. of the public vaccinators awards of money have been made from the Parliamentary grant as additional payment earned by the excellence of their work. Details as to the several unions will be found in the second of the appended papers.

National Vaccine Establishment.

The department has continued during the year the administration of the National Vaccine Establishment, receiving, according to its original plan, charges of lymph from certain specially approved public vaccinators whose operations are supervised by Dr. Stevens on behalf of the Board. The demands on the establishment were somewhat unusually great, owing to new appearance of small-pox in several parts of the country; and for a time it was necessary to obtain supplies from other vaccinators than those usually on the staff. Out of 26,557 charged tubes which were received during the year, 9,038 were obtained from these additional sources. The tubes were carefully examined in the department, and the fact of their being well sealed and the lymph being clear and free from blood was ascertained before any tube was allowed to leave the office. Charges to the number of 24,572 tubes, besides 8,195 points and 40 glasses, were sent from the establishment in reply to 12,468 applications. The lymph has been distributed to practitioners in the United

MEDICAL OFFICER'S REPORT.

Kingdom, and the Army and Navy, as well as to India, the Colonies, and Foreign services. Particulars of the source and distribution of lymph will be found in Appendix A., No. 3.

Representations of want of success with this preserved lymph have been received from four per cent. only of the practitioners to whom it was issued. Representations as to irregularity of result in the use of this lymph have been made by one practitioner only, who, on inspection of a particular child vaccinated in the previous week, found "some eczematous crusts in the place of "normal vesicles."

II.—ANIMAL VACCINATION.

Animal Lymph Establishment.

Dr. Cory reports the preliminary proceedings of the Animal Vaccine Establishment. Beginning with the approved lymph-stock of Dr. Carsten of The Hague, Dr. Cory vaccinated during the latter half of 1881 and the first two months of 1882, a succession of 46 calves with fairly good results; and forwarded to the Board a total of 975 charges, of which 500 were sent out to 96 practitioners who desired it. He gives in his Report (Appendix A., No. 5) a history of the operations of the station and the descent of the lymph. Of the effects produced by the lymph in the hands of the practitioners to whom it was sent it is not possible to give any useful account; but Dr. Cory, in the few experimental uses he made of the lymph at St. Thomas's Hospital, succeeded, after a little experience, in obtaining fairly complete results with it when he stored it on points and used it within five days of its being taken from the calf. The character of vesicles and of resulting scar were satisfactory. Stored in tubes, the lymph did not give him the same degree of success.

Dr. Cory further reports on a new lymph furnished by Dr. Dubreuilh, of Bordeaux. The first sample of this lymph was only 17 removes, through the calf, from a "spontaneous case" of cow-pox. Comparative inoculations with it and with lymph of the Hague stock has led Dr. Cory to give preference to the Bordeaux lymph-stock, and at the date of this report that lymph is being cultivated from calf to calf with excellent results, in supersession of the Hague stock.

A memorandum distributed with each charge of calf lymph given from the establishment will be found in the Appendix to this Report (page 39; *see also* pages 24–25).

III.—SMALL-POX IN LONDON IN 1881.

Small-pox in London; Incidence on vaccinated and unvaccinated.

In June 1881, on the occasion of a twelvemonth having passed since the Registrar General began to record what he could learn about vaccination in the case of deaths registered in London from small-pox, I had the honour to submit to you a memorandum on the relative mortality from small-pox in the vaccinated and in the unvaccinated inhabitants of London.

This memorandum was presented by me to Parliament and extracts from it are reproduced in the Appendix (No. 7) to the present report. Its principal facts were summed up as follows:— Memorandum laid before Parliament.

COMPARATIVE SMALL-POX DEATH-RATES among LONDONERS VACCINATED and UNVACCINATED respectively, for the 52 weeks ended 29th May 1881.

Death-rate of People of enumerated Ages.	Per Million Persons of the Ages in the Vaccinated Class.	Per Million Persons of the Ages in the Unvaccinated Class.
All ages - - - - - -	9	3,350
Under 20 years - - - - -	61	4,329
Under 5 years - - - - -	40½	3,250

It was beyond the scope of the memorandum to record the completeness or incompleteness of the vaccination in the case of those recorded as dying after vaccination. The above summary figures related to "vaccination" in the aggregate. The power of a thorough vaccination to protect against death from small-pox is at least ten times greater than the power of much that passes under the name of vaccination, but the paper was not concerned with this difference.

The Board, however, had another interest in observing a mortality from small-pox, whatever might be its degree, among the vaccinated. It was important to learn how far such mortality might be attributable to any faults within the system of public vaccination which the Board is charged to administer. Accordingly, at my request, Dr. Stevens undertook, during the year 1881, an examination of all the small-pox deaths occurring in the houses and hospitals of London, with inquiry (in which he was aided by the vaccination officers) as to all the deaths among people alleged to have been vaccinated or whose vaccination was doubtful; and with more detailed personal inquiry into the cases of people who were said to have been vaccinated by public vaccinators during the working of the Vaccination Acts of 1867 and 1871. Dr. Stevens's inquiries.

Dr. Stevens has given me a number of tabular statements and notes concerning the small-pox mortality of the year 1881. (Appendix A., No. 8.) The total number of deaths is given by him at 2,379; it is recorded at 2,371 by the Registrar General during the 52 weeks of the year. These numbers include 31 deaths in persons brought into London hospitals from beyond the metropolis. Of the 2,348 deaths of Londoners, 1,526 occurred in hospitals, 822 in the homes of the patients; being 65 and 35 per cent. respectively. Of the gross 2,379 persons who died, 678 were taken ill while resident in the union or parish in which they were born; the remaining 1,701 were not so resident at Small-pox mortality statistics.

MEDICAL OFFICER'S REPORT.

the time of their attack. There is a good deal of importance attaching to the mobility thus indicated of the population, especially as it affects children; but upon this I do not at present insist.

Out of the 2,379 deaths, children under fifteen numbered 1,125, or not quite half the total number; children under ten numbered 953; under five, 667.

Relative incidence on children less than formerly.

Formerly, in the 20 years before 1871, when public vaccination was gratuitously provided, but when compulsion was little more than nominal, more than half the deaths from small-pox that occurred in London were of children under their fifth year. In the ten years, 1851–60, these children contributed 59·5 per cent. to the all-age small-pox mortality of the metropolis, and in 1861–70 they contributed 54·3 per cent. In the year 1881 (when, I repeat, not quite half the deaths were contributed by children under 15), children under five contributed only 27·8 deaths to every 100 deaths from small-pox in the metropolis. These figures will show that it is especially to the advantage of children that vaccination has been made compulsory. For in the year 1881, the unvaccinated suffered from small-pox (as the above quoted table will have shown) immensely in excess of the vaccinated; the difference between the two classes, observable at every age, being most observable at younger ages.

Small-pox mortality among children under 10:

Taking now with Dr. Stevens the calendar year 1881, and examining for the metropolis the mortality from small-pox, I propose to restrict my own observations to the experience he brings about children under 10 years of age. I do so on this occasion for two reasons: as I wish to take account of the more active enforcement of vaccination that began ten years ago; and as I am not proposing now to discuss any question of waning influence of vaccination, or need of re-vaccination.

The population of London under 10 was 916,784 on census night 1881. It divides, to speak in round numbers, into about 55,000 unvaccinated and 861,000 vaccinated.*

in vaccinated compared with unvaccinated;

In 1881 the small-pox deaths of London among children under ten turns out to have been: (*a*) 782 deaths among the 55,000 who had not been vaccinated; (*b*) 125 deaths among the 861,000 who had been vaccinated. Upon equal numbers

---

* For the grounds on which this numerical division of the population is made, I refer to the text of the above-quoted memorandum. The estimate of the number of unvaccinated is probably too high, making the rate of death among the unvaccinated lower than the truth. But I am anxious to avoid any appearance of exaggerating their death-rate.

Dr. Stevens, "in fairness to the vaccination officers," directs attention to the fact that of the deaths among the unvaccinated there were 126 among children of three months of age and under,—a time of their lives when many of them might indeed have been vaccinated, but when they were not old enough to come within the sphere of the vaccination officer's duty.

The fact of vaccination or no vaccination was learned in the case of two or three hundred of the deaths under 10, not from death registers but from house inquiry made by the vaccination officers. In the case of 46 small-pox deaths, however, the fact could not be learned at all; and the above figures, 782 and 125, together fall short of the total 953 by this number 46.

of the two classes, therefore, the mortality from small-pox among the unvaccinated was about a hundredfold the mortality from small-pox among the vaccinated. This degree of protection was given to children under 10 by the average current vaccination of London.

London vaccination, however, has to be considered as being of divers sorts; and Dr. Stevens's inquiries have taken account of these. The 125 children under 10 who died of small-pox after an alleged vaccination, have to be reduced to 117 by deduction of those who were discovered on his personal inquiry not to have been vaccinated at all, or to have been "unsuccessfully" vaccinated; and this number 117 divides into 82 vaccinated by private practitioners, and 35 vaccinated by public vaccinators. Now the number of vaccinated children under 10 in London is made up in about equal numbers of those vaccinated by private practitioners, and of those vaccinated at the public expense. Among the privately vaccinated there were 82 deaths, among the publicly vaccinated there were but 35.*

In the publicly compared with the privately vaccinated.

From these figures we may deduce the fact, creditable to public vaccination in London, that it protects against small-pox much more than private vaccination. The difference between the two, however, deserves a little more consideration. Children privately vaccinated comprise most of the children of the upper classes, who certainly run less risk of small-pox infection than the poor. The comparatively large mortality among those privately vaccinated therefore becomes the more striking. Some of such children are doubtless vaccinated efficiently enough, and are protected from small-pox as completely as any of those vaccinated at public stations. But we who have much to do with the total vaccination of London know of a particular source of inefficiency in private vaccination, of a sort to be responsible for a relatively high mortality from small-pox. It consists in a form of private vaccination that offers itself in competition with public vaccination, and which parades its inefficiency as a reason for its acceptance by ignorant people. Its professors say to young mothers, "Do you come to me, and I won't hurt your baby; I'll "make only one place on its arm, not four, as those public "vaccinators do." And undoubtedly there are medical men to be found who, having formed some opinion of their own about the sufficiency of one vesicle, cannot be induced to set aside that opinion in deference to the indisputable evidence to the contrary that every small-pox hospital holds up to them.

A cause of inefficiency in private vaccination.

Dr. Stevens goes on to examine the 35 cases where death

* Deduced from the returns of public vaccination, the number of London children under ten vaccinated at the public expense would appear to be greater (in the proportion of 53 to 47) than that of children privately vaccinated. But as we are considering the whole vaccinated community up to the age of ten, and the children gratuitously vaccinated, being mostly poor, have doubtless not survived up to their tenth year in the same proportion as the children of those who pay for vaccination, it has been thought well to regard the vaccinated population under ten as being made up of equal numbers of publicly and privately vaccinated.

MEDICAL OFFICER'S REPORT.

from small-pox is reported to have occurred among children under 10 years of age vaccinated by public vaccinators. It turned out upon inquiry that 12 of these 35 had never been vaccinated until after they had been exposed to small-pox infection, when it was too late to protect them against catching the disease, and too late to modify its virulence. There remained 23 instances, and only 23, in which the question arose, "Why did "public vaccination fail to protect from death by small-pox "during the first 10 years of life?" Dr. Stevens's notes enable a reply to be given to this question in the case of a good many of the children, and they are worth consulting (Appendix, page 52), as showing to what small dimensions the failure of public vaccination has dwindled. The record of small-pox deaths among children under 10 vaccinated by public vaccinators now proves to be made up (*a*) of two cases that could not be traced, and, in almost equal numbers, by (*b*) cases where the child was ill of some independent disease before the occurrence of what was registered as small-pox (in a few it is doubtful whether small-pox was present at all), and (*c*) cases carrying scanty and imperfect marks on their arms though done by the public vaccinator. There was one child, and only one, of whom it could be said that vaccination had apparently been performed in the manner contemplated by the Board's instructions, and yet had died of small-pox contracted while it was in its usual health. That there should be a stray case of the last kind is no wonder; such cases find their parallel in those occasional instances where small-pox itself attacks a person, even severely, and yet leaves him liable to death from a second attack of the same disease after a few years' interval.

Protection to children by public vaccination.

We may ascribe, therefore, a part of the 35 deaths, but only a small part of this very small number, to unsatisfactory quality of vaccination, as done in some instances by public vaccinators. But, the very great bulk of the vaccinations performed by public vaccinators have been protective against death by small-pox during the recent epidemic, and the creditable account which Dr. Stevens brings from inspection of their actual work is endorsed by the evidence of the death returns.

Saving of children from death by small-pox:

I would once again state explicitly, for general information, the extent to which London children have profited by vaccination, as they received the operation from the aggregate of medical practitioners during the recent epidemic. I shall continue, for the reasons I have already given, to speak only of children under 10, and be content to ignore all question of advantage given by vaccination to persons of later age.

It has already been said that in 1881, among the 55,000 children who had not been vaccinated, there were 782 deaths from small-pox; among the 861,000 children who had been vaccinated, that there were 125 deaths from small-pox.

If the London children under 10 who were unvaccinated had had the protection which the current vaccination gives, not 782

of them, but at the outside *nine*, would have died of small-pox during the year.

If the 861,000 vaccinated children had died at the rate of the 55,000 unvaccinated, we should not now be considering 125 small-pox deaths and how they can be reduced, but we should be confronted with an additional 12,000 and more deaths from small-pox, occurring during the year in the London population under 10 years of age.

can only have been due to vaccination.

This saving of life was essentially the effect of vaccination. If anyone should advance the opinion that the vaccinated may have owed their escape from death by small-pox, not to their vaccination, but to their belonging to that richer class of the community which, through being better lodged and guarded, is less exposed to the infection of small-pox, the reply is at hand. Let us consider separately the class of the population which has its children vaccinated at the public expense. We know that it is not less than half the population, and that almost the whole of the poorer population is included in this class. No one will say that this half is the better housed or its children more out of the way of infection, or that its children can command better aids to recovery, if they should be attacked.

The children under 10 living in London and having been vaccinated at the public expense number about 430,000. If the rate of death which prevailed among the unvaccinated children of London had prevailed also among this section of the vaccinated, then, among these vaccinated children there would have been more than 6,000 deaths from small-pox last year. But out of these children, being in chief part children of poorer class, what was the number of deaths that actually did occur from small-pox? Not six thousand, nor one thousand, but at the outside 35; more truly 23, for 12 of them were not vaccinated till small-pox had actually taken hold on their bodies.

In spite, therefore, of any greater exposure to small-pox undergone by the poorer half of the vaccinated community, it is seen that the poorer half had actually less mortality from small-pox among its children than the richer half; and the opinion that the escape of the vaccinated from death by small-pox was due to any smaller risk of small-pox infection encountered by the vaccinated as compared with the unvaccinated may be confidently set aside.

and largely to the operation of vaccination law.

The saving of life which I am now recording is a saving of 12,000 lives by vaccination to children under ten years of age in London in 1881. It is not to be disputed that this saving by vaccination is in great measure due to the operation of the Vaccination Acts of 1867 and 1871. The same operation of these Acts is manifested in the before-mentioned change in the age of people who die from small-pox in London. In the two periods of ten years immediately preceding 1871, 59 and 54 per cent., more than half, of the total small-pox mortality was borne by children under five years old: now only 28 per cent., little more than a quarter, of the total small-pox mortality falls upon such children.

A small set-off against the great benefit of vaccination.

But can it be asserted that this saving of life has been too dearly purchased, and that injurious effects of vaccination counterbalance its advantages? The Registrar-General has recently, by an improvement in his nomenclature, enabled account to be taken of all the deaths ascribed to vaccination and its consequences. A measure is thus afforded of the injury done by vaccination, careless and careful together, and the deaths thus recorded have to be set off against the saving of life demonstrably effected by vaccination.

In London, in 1881, 12 deaths were registered as from "cow-pox" and disease occurring after vaccination. Inquiry into the facts of the several deaths showed that the cause of death was, with hardly an exception, erysipelas; derived from one or other source and seldom even dating from the vaccination.

Supposing all the 12 deaths had been justly attributable to vaccination, and had been unavoidable results of vaccination, then 12 lives lost by vaccination have paid for the gain of 12,000 children's lives that would, but for vaccination, have been sacrificed to small-pox; not to mention any gain of security after childhood, afforded by vaccination in infancy. The price has not, in truth, been so high as this; but the complete abolition of every such drawback to vaccination is the aim of everyone who appreciates the value of the operation.

IV.—Inquiries as to Local Prevalences of Disease by Inspectors.

Dr. Ballard's Diarrhœa inquiry.

During the year 1881 an inquiry of much importance to the general sanitary welfare of the kingdom has been begun in the Medical Department. Dr. Ballard was engaged on an investigation of the nature and causes of epidemic diarrhœa. The need for this inquiry, long seen to be pressing, had been made more urgent by the unusually high mortality produced by the disease in 1880.

Of the ten, twenty, or thirty thousand deaths from diarrhœa that are recorded each year in England, the great majority are contributed by young children, and the bulk of the mortality is in the third quarter of the year in the large towns of the kingdom. Among these towns, Leicester has for a long time been pre-eminent for its high death-rate from infantile diarrhœa, and it has accordingly been selected as the place in which the fullest study can be given to the conditions under which the disease prevails and proves fatal. At the same time, investigation is being made into the circumstances of other towns in which infantile diarrhœa is present either to a similar extent or to a very different extent, and the conditions observed in Leicester and the several towns are being compared and studied together. A large scheme of inquiry has thus been organised by Dr. Ballard, and I have the satisfaction to report that in pursuit of his object he has secured the interest and co-operation of many sanitary authorities and medical officers of health as

well as of other members of the medical profession. In 1881, during the months of chief mortality from diarrhœa, he further had the assistance of the Board's inspector, Mr. Power, in examining the conditions of prevalence of fatal diarrhœa in Leicester.

Dr. Ballard has thus, with the aid of a small band of cordial fellow-workers on whose accuracy he can depend, entered on a systematic study of this disease, hitherto so little explored, though so lamentably fatal to our infantile population. An immediate result from his labours is not to be expected; the inquiry is too complicated and by necessity extends over too wide an area; besides that much of it can be carried on only during the period of special prevalence of the disease each year. Probably indeed, the first results must consist in the removal of some obstructing current beliefs on the subject. But the inquiry is well worthy of the time and pains that it is intended to bestow on it, for by its means we may hope to learn how English towns may greatly diminish their mortality from "summer diarrhœa." There are at the outset some indications that the causes of the disease will prove to be, in an important measure, within the province of public sanitary measures.

Among the many local inquiries which have been made for the Board by the Inspectors of its Medical Department, 29 have had reference to special outbreaks of disease or to the general sanitary state of districts. From the reports on these inquiries made by Inspectors, I select several that are of more than passing interest to accompany this report.

A case of sausage poisoning in a man resident near Chester was investigated by Dr. Ballard, who gives (Appendix A., No. 9) the history of the resulting disease as witnessed in the man, while Dr. Klein records the effects upon animals of feeding them with other portions of the sausages. The case is found to contrast markedly with those of the Welbeck and Nottingham outbreaks previously reported on by Dr. Ballard.* In this instance, the course and symptoms of the observed disease, and the post-mortem appearances in the animals which were the subject of experiment, find their analogies in the operation of a chemical poison; whereas in the earlier instances the phenomena of the resulting illness were rather those of an acute specific disease—one that had certain resemblances to enteric fever.

A case of sausage poisoning: Dr. Ballard.

Reporting on an epidemic of scarlatina in Halifax (Appendix A., No. 10), Dr. Ballard has to tell of some customary and of some exceptional features in the prevalence of the disease. It was found to have spread through the town, for the most part through the usual intercommunication of infected with susceptible persons, by the agency of infected articles of clothing and the like; the merest pretence of action having been taken by the sanitary authority of the town for its repression. But it was seen to show

Scarlatina in Halifax: Dr. Ballard.

* See pages 36 et seqq. of the Medical Officer's Report for 1880 (Supplement to tenth Annual Report of Local Government Board).

MEDICAL OFFICER'S REPORT.

specialities of incidence both in time and place,—specialities that had been noted by the local health officer and regarded by him as indicating a relation to a particular milk service. Dr. Ballard's enquiry confirmed this suspicion. He found the milk in question to have been obtained from healthy cows which were milked by a dirty servant living in a cottage crowded with cases of scarlatina. The distribution of the milk by this same servant (who carried it out to customers, dipping it out of a can) was found to coincide in a marked manner with the excessive distribution of scarlatina over particular localities in the town. The experience of this epidemic is one out of several indications, that the spread of scarlatina is aided more commonly than is supposed by mismanaged milk-businesses; and it confirms the policy of vesting in sanitary authorities the function of regulating such businesses.

Scarlatina in and about Durham: Mr. Spear.

A very high mortality from epidemic diseases, particularly from scarlatina, in the Durham Registration District, was the subject of inquiry by Mr. Spear. The part of his report which deals with scarlatina takes cognizance of a special incidence of that disease, in its fatal form, upon the whole county of Durham; and Mr. Spear presents a number of considerations, principally involving questions of susceptibility and immunity, that have a more than local interest. This portion of Mr. Spear's report forms one of the appended papers (page 70).

Enteric fever at Blackburn: Dr. Airy.

A report presented by Dr. Airy on the causes of an outbreak of enteric fever at Blackburn, records how the public water supply of the district was liable to several local contaminations. Dr. Airy tells particularly of certain distant privy pits from which there had probably been escape of foul matters into a reservoir; and how, if there had been such escape, it must needs have involved the pollution of the water by the specific material of the fever shortly before the outbreak. Comparing the actually observed distribution and intensity of the fever in the town with the distribution and intensity to be expected if the spread of the fever were due to the oozings of the infected privies into the public reservoir, Dr. Airy finds some noteworthy resemblances between the two. (Appendix A., No. 12.)

Enteric fever at Melton Mowbray: Dr. Blaxall.

In interesting contrast to the Blackburn outbreak was a prevalence of enteric fever at Melton Mowbray that was the subject of inquiry by Dr. Blaxall. In the former, cases of the fever were scattered about the town with a fairly equable incidence over extensive districts; the peculiarity of the outbreak being the way in which the fever appeared simultaneously over large areas, and then disappeared as an epidemic after a few weeks of graduated prevalence. In the case of Melton Mowbray, the fever was found by Dr. Blaxall to have been confined to a particular portion of the town which it attacked with major intensity on three several occasions separated from each other by intervals of two or more weeks during which a stray case only occurred. Dr. Blaxall gives reasons for believing the chief

vehicle of distribution of the fever-material in this case to have been not water or milk, nor air from particular privies (though all these may have played a minor part), but air from a section of the town sewers that was not ventilated according to its special needs, and had, after receiving fever-infection, become choked by floods on three occasions, each preceding by a fortnight the time of special intensity of the fever. (Appendix A., No. 13.)

MEDICAL OFFICER'S REPORT.

Small-pox at Bourne Bridge: Dr. Airy.

Dr. Airy records (Appendix A., No. 14) the history of a family attacked by small-pox in February 1881 at Bourne Bridge in the Ongar Union. A suggestion had been made that the disease was in some way related to diseased sheep, but this was disproved by Dr. Airy. For the rest there is nothing exceptional in the story of small-pox in the family, beyond the evidence of its remarkable intensity. The chief interest of Dr. Airy's report on the case lies in the account he gives of a person resident in a second house, who got small-pox shortly after the attacks in the first family, and in the evidence which has inclined Dr. Airy to think that the second house really received its infection from the first house, owing to the conveyance of infectious matter by the wind over the intervening distance.

Infectious disease among rag-sorters: Dr. Parsons.

Dr. Parsons, in pursuance of instructions to inquire into an outbreak of small-pox among rag-sorters at St. Mary Cray Paper Mills, had occasion to examine a variety of sanitary reports and other literature for instances in which infection has spread by means of rags, and he has made a report on the general subject (Appendix A., No. 15). He gives the frequency of this occurrence as somewhat greater than it has been usually represented, the observed infection being in almost all cases that of small-pox. In his report he considers the way in which infected rags find their way into paper-mills, and the circumstances which influence the spread from them of infective particles; and he states in detail, with a view to the practical usefulness of his conclusions, certain precautions which can be taken in the mills for preventing the spread of disease from rags. Dr. Parsons has thus added a useful chapter to Dr. Ballard's reports upon Trade processes in their influence upon health.

V.—Various Administrative Proceedings.

Hospital reports: Dr. Thorne and Mr. Power.

A great part of the year 1881 was spent by Dr. Thorne in an inquiry into the use and influence of hospitals for infectious diseases, and Mr. Power was engaged for several months in an investigation of the influence of the Fulham Small-pox Hospital on its surrounding neighbourhood. Reports on these subjects have already been submitted to you in supplement to the Tenth Annual Report of your Board; and at the present time, in so far as these reports have concern for the Metropolis, they are under consideration by a Royal Commission.

MEDICAL OFFICER'S REPORT.

Trichinous disease and cooking of meat.

In the early months of 1881, rumours as to the importation into Europe of articles of food derived from pigs infested with trichinæ gave rise to some disquietude among the English public, and were the occasion for very comprehensive action on the part of certain continental Governments. In England, however, no evidence was forthcoming that any disease, of the sort to be expected from the consumption of such articles of food, had occurred; and under all the circumstances, the English Government was content to be on the watch, and to impress upon the public that they had in their own hands the principal means of escaping danger of the apprehended sort; and this equally whether native or foreign animals were in question. In March a memorandum (Appendix A., No. 16) was prepared in the Medical Department, insisting on the importance of thorough cooking of meat as a means of security always available against trichinous disease; and this memorandum was distributed to sanitary authorities throughout the kingdom. In a short time public anxiety on the subject wore away; and throughout the year, the Board with all the opportunities afforded by their relations with local health authorities, did not hear of any trichiniasis occurring among the English population.

Subjects referred to Medical Department,

In the exercise of the functions habitually entrusted to the Department of advising on plans for hospitals, on proposals for byelaws, on questions arising out of health officers' reports and the like, local inquiry by medical inspectors has been undertaken on 29 occasions during the year. These were instances where, the Board's sanction being in question, information on local sanitary points was required by the Board.

Such inquiries had reference to :—

involving local inspections.

1. The appointment of district medical officers to be medical officers of health. Inquiries into proposals which had this object have justified the Board's objection to sanitary duty being regarded as attaching in anywise *ex officio* to the business of a district medical officer; and they have also led to a strong general preference for single over multiple officers of health in the case of sanitary districts having the constitution of the present country districts.

2. The combination of several sanitary districts for the purpose of employing the same medical officer of health. In the one local inquiry of this sort that was made by the department, particular areas were adequately served by their health officers, but others were not so; and combination promised to afford to all and each of the districts, without extravagant cost, the services of an officer who should be specially skilled in sanitary knowledge, and who should have the peculiar facility for putting such knowledge to its best use that is possessed by a health officer independent of private medical practice.

3. Local hospital accommodation for infectious sickness. Seventeen inquiries into this subject matter were made by

medical inspectors; with reference to (*a*) suitability of proposed sites for the purchase of which sanitary authorities desired to borrow money; (*b*) the transfer of existing buildings to serve as hospitals for sanitary authorities; (*c*) proposals for joint use of hospitals by combining sanitary authorities.

4. A variety of medical questions involved in proposals for byelaws, in modifications sought to be made in existing byelaws, in the choice of site for cemetery, in the administration of slaughter-houses.

Proposals for Local Acts: Disease notification.

It has been my duty on several occasions during the past year to advise your Board respecting the sanitary powers proper to be conferred by special legislation upon local authorities in extension of the provisions of the Public Health Act, 1875, and other general Acts. One of the more usually desired powers of this sort has been that of obtaining immediate information of the existence of infectious disease in any house. Seeing how greatly the usefulness of sanitary action in respect of this class of disease must depend upon early knowledge of its presence, I have had no hesitation in advising that this power might properly be possessed by any sanitary authority who wanted it, and who, having made adequate arrangements for securing isolation and disinfection for the district, was prepared to put to effectual use the knowledge which a system of disease notification would afford.* A variety of other sanitary powers relating to infectious disease have been applied for by one and another health authority. The conditions for the enforcement of these powers, and the extent to which the public health is promoted by the exercise of them, will deserve careful observation in the future.

School closure and exclusion of scholars.

The new Code of the Education Department of the Privy Council, dated March 6th, 1882, contains a provision of importance in local sanitary administration. Article 98 instructs the managers of public elementary schools throughout the country to conform to any notice they may receive from the local sanitary authority, requiring them to close the school or to exclude any scholars from attendance. There can be no question that the power thus conferred on sanitary authorities will, in certain localities and during particular epidemics, be of great advantage in preventing the dissemination of infectious disease, and it is proper that the power should be vested in them. But I may be allowed to indicate the necessity on the part of sanitary

* Question has also arisen as to the propriety of investing all sanitary authorities with the same power of requiring notification of infectious disease, but it will probably be desirable to await further experience before this is affirmed. Herein I would observe that very few sanitary authorities have made byelaws in this subject-matter, under the powers of sect. 90 of the Public Health Act, 1875. Such byelaws would, it is true, have had application only to the case of houses let in lodgings; but this is precisely the class of houses where most direct advantage from disease notification is to be expected. It is to be regretted that we are without experience of the merits and failures of a system which requires—as concerns this particular class of house—that the householder should report to the sanitary authority the occurrence of cases of infectious disease.

authorities and their medical advisers for an accompanying sense of responsibility in their dealings with schools. Heretofore it has not been uncommon when measles or scarlatina has appeared in a district to propose the closure of schools as mere matter of course. Henceforth, when the representations of sanitary authorities will be, in a measure, binding on the managers of a school, the sanitary authority will ask to be shown a clear prospect of sanitary gain before interfering with the educational operations of their district. They will need to feel the reasons why closure of any particular school is to be desired, and why the object of hindering infection is not to be attained by the less comprehensive measure of prohibiting the attendance of children from houses or streets that are known to be infected.

Closure of a school not to be lightly ordered.

Proposals for more statistical forms for use by medical officers of health.

During the year representations have been received from the North-Western Association of Medical Officers of Health and from others desirous of putting their experience to the best use, to the effect that there would be advantage in the issue by the Board of model forms for the analysis of local statistics, in addition to the forms already appointed for the use of officers of health who are subject to the orders of the Board. The memorialists had in view two principal objects; the one to ensure a general record of rates upon population as well as actual numbers of sickness and mortality; the other to secure a general uniformity and comparability of the statistics of one and another district. In advising the Board respecting this proposal, it has been my duty to consider, not only the abstract desirability of the objects sought to be attained, but also the expediency of the proposed means of obtaining them; and I have not thought it desirable that the Board should issue more forms to be filled as matter of duty by all officers of health who are subject to the Board's orders. As respects tabular records of rates as well as of actual numbers, it has appeared to me that such rates as are worth the reckoning are at present habitually recorded by local health officers: rates that are not stated being commonly rates upon small populations during short periods of time, such as are of no significance for any general purpose. As respects the second object which the memorialists seek to attain, I need hardly point out that the holder of my office has a very peculiar interest in encouraging all legitimate uniformity of tabulation. He, at least as much as any officer of health, is concerned with comparisons and contrasts and with the lessons they teach. And the fact of two tables being already appointed for use throughout the kingdom may suffice to show that uniformity is valued, while the object of assisting less experienced health officers in noting the statistical points most deserving of their attention is fully held in view. The only question can be as to the extent to which such uniformity should be enjoined upon all officers of health. No doubt the reader of local health reports is conscious of perplexing differences of tabular statements, differences that at first sight appear avoidable. But the local usefulness of these reports is

ject to be sought, and a uniformity that puts s into the background is not to be desired. or of water service in one district, occupational ber, circumstances of race or habit in a third, more especially considered in connexion with prevalence or fatality of one and another kind der to teach in the best way the lessons that , tabular records (beyond the most elementary adapted to this variety of local circumstance. Uniformity of tabulation, to the extent of setting aside a health officer's personal preferences for the sake of serving a common object, is unquestionably to be sought; but the end now desired can, I think, be better attained by health officers in counsel with each other, as in local societies, than by the appointment, by a central office, of forms professing to be adapted to all sanitary districts of the kingdom.

VI.—Auxiliary Scientific Investigations.

A report by Dr. Cory (Appendix B., No. 1) on the evidences which chemistry can give as to the presence of certain pollutions of water, where such pollutions have been purposely made, will be of interest to the Board, while it is full of instruction for local sanitary administrators.

Into evidences offered by water-analysts: Dr. Cory.

The Medical Department has had repeated occasion to observe, on the part of sanitary authorities and their advisers, a tendency to estimate unduly the value of quantitative chemical analyses as demonstrating the wholesomeness of drinking waters. Some authorities have even regarded evidence of this sort as setting aside presumptions of pollution that had arisen from considerations of dangerous situation of wells and reservoirs.*

The refined methods of water analysis that are now in use are capable of detecting very minute quantities of organic impurity in large volumes of water. They enable a total amount to be stated, and from some of them, moreover, inferences can be drawn as to the proportion of such impurity that is of animal origin.

Now there is nothing in the nature of things that constitutes a grain or a fraction of a grain of organic matter, vegetable or animal, into an indication of wholesomeness or unwholesomeness, because it occurs in a gallon of water. It is because we have a previous knowledge of where the organic matter of water is likely to have come from, that we want to have our drinking waters as free as possible from all such matter, and particularly from all that is of animal origin. We know that excrement and such nastiness is the usual source of the animal matters discovered in our drinking waters.

---

* Dr. Frankland, in the memoranda with which he accompanies his reports of analyses, takes care to show that the origin of waters must be held in view when interpreting chemical results.

MEDICAL OFFICER'S REPORT.

And just as this previous knowledge has always lain at the very basis of our care about organic purity of water, so with advance of our knowledge we have learnt that among animal impurities of a nasty kind, one differs very much from another in its power to give a morbific quality to water. We have come to be especially desirous of avoiding such impurity, if any part of it can have been derived from the bodies of persons suffering under communicable disease.

If we could be sure that waste products contaminating water were by no possibility derivable from any but healthy bodies, we might perhaps run no very serious risk if our water were as foul as that of the Holy Well of Mecca,—stuff saline with urine and yielding to analysis "nearly six times as much animal matter as is found in the same volume of strong London sewage."* But with the introduction of the idea of specific disease the conditions are totally changed. We do not know how small a quantity of material that has been in relation with such disease may, when it gains admission to a healthy body, suffice to produce like disease in that body. We have no reason for believing that the quantity of disease-producing material in a water, or the likelihood of the water possessing harmful qualities, is proportionate to the total organic matter or to the total animal matter present in the water. The utmost we have been able to say is that there has been greater opportunity for the entrance of the material of disease into water that can be recognised by the chemist as foul with organic matter, and we have surmised that the material of disease on entering such water may obtain opportunity of sustaining or multiplying itself.

Waters prepared for analysis by intentional pollutions.

In proceeding to study afresh the nature of the evidence derivable from chemical analysis of water, as at present conducted, Dr. Cory prepared a series of samples by the intentional addition of various polluting matters in known quantity to certain known waters, and submitted these samples with specimens of the original waters to Dr. Dupré for chemical examination. Also, when processes regarded by particular chemists as of special value were in question, he had the advantage of obtaining from these chemists themselves, differential analyses of his polluted and unpolluted specimens.

Dr. Cory kept accurate note of each step of his proceedings, of the results announced by the chemists, and also (though these have to be regarded as little more than incidental) of the microscopical appearances observed in his water samples; and he has put the facts on record, with comments upon the particular experiments and upon the whole series.

Estimate of value of several processes.

Among the processes ordinarily made use of for examining the organic matters present in drinking water, Dr. Cory assigns a certain inferior value to the Forchhammer permanganate test

---

* Frankland.

for oxidizable matters, regarding it as useful when certain known conditions are fulfilled. And he would assign a similar value to the more delicate Wanklyn process for "albuminoid ammonia," trusting it to show much respecting the relative degrees of pollution in samples contaminated with the same kind of material. But Dr. Cory distinctly gives preference to the Combustion processes; those, namely, which aim at determining the amounts of carbon and of nitrogen present in the organic substances of water. Experimenting with materials, albumen and urea, of which the composition was known, Dr. Cory found those processes to indicate with a considerable degree of accuracy the true amounts that he had added to his samples of water; and to show the ratio between the elementary carbon and nitrogen with a close approach to the truth.*

Many of Dr. Cory's observations had reference to experimental contamination of waters with the stools of enteric fever patients. There is peculiar practical interest in these observations, owing to the special faculty of this disease to spread by means of drinking water. Whatever may have been the origin of the malady apart from an antecedent case, everybody is familiar with instances where extensive epidemics have been due to the accidental introduction into drinking water of matters evacuated from the bowels of persons previously ill of the disease. I select therefore from Dr. Cory's Report some information that he and Dr. Dupré afford respecting the results of intentional water pollution by the stools of patients having enteric fever.

It is found in the first place that to the customary methods of chemical examination, there is nothing to distinguish this pollution from any other excremental pollution; for the circumstance of the chemical evidences of a fever stool being smaller in amount than those of an equal quantity of healthy stool of like consistence does not aid in the distinction. Indeed generally, Dr. Cory's report gives no indication that chemistry can tell whether a healthy or a diseased body has been the source of any foulness observed in water.

This is true of all the processes which have been put on their trial in the course of Dr. Cory's observations. But in quoting the information he brings respecting the chemical results of specific pollution of water by enteric fever stools, I shall conveniently restrict my comments to the process which is most popularly trusted for the recognition of animal impurity; the amount of "albuminoid ammonia" yielded by the water. Applying this process to a water which had been purposely diluted with enteric fever stool in the proportion of a grain to a

* Dr. Dupré has, as was to be expected, used the experience of the present investigation, for introducing some improvements in certain methods of analysis before conducted. (Appendix, p. 160 *et seq.*)

MEDICAL OFFICER'S REPORT.

gallon,* Dr. Dupré's analyses show a resulting increment of albuminoid ammonia (on an average of experiments) amounting to one thousandth of a grain (·0010) in the gallon; or, what is the same thing, to fourteen thousandths (·014) of a part per million parts. A particular sample of water purposely contaminated with the filtrate from 3·5 grains of fever stool to the gallon was submitted along with a specimen of the water not thus contaminated to Mr. Wanklyn, the chemist by whom the albuminoid ammonia process has been developed. The increase resulting from this pollution proved to be ·020 part per million for the 3·5 grains, or ·0057 part per million for each grain of the contaminating stool added to the gallon of water; something less than in the average experiment with filtrates.

It is worth while to regard these chemical experiences in their application to an actual case, for the sake of a better understanding of such figures. In an outbreak of enteric fever at Caterham two years ago,† nearly 200 earlier attacks were traced, upon evidence that did not admit of question, to the use throughout a particular fortnight, of water that had been pumped from a well in which a man having enteric fever had been at work. Some excremental matters from him had by accident got into the well. Now I learn through the Chairman of Directors of the Caterham Waterworks Company that 1,861,000 gallons of water were pumped from the well during the fortnight. If the water had for the whole fortnight contained one grain of excremental matter per gallon, this would have meant that 19 lbs. of excrement had been added to each day's supply of water. It is of course out of the question that the man evacuated any such quantity; neither is there any reason to suppose that every gallon received the same amount of contaminating matter; but the story may serve to show that in speaking of one grain in the gallon, we speak of a very large amount of polluting matter present in the water. It may be thought of as an amount not likely to have been exceeded in the particular samples of Caterham water that did actually produce disease in the individuals who drank it.

Specific pollution present in dangerous amount,

In Dr. Cory's experiments, then, with one grain of enteric fever stool per gallon, we see a water thus largely befouled by a

* The polluted waters were allowed to deposit their coarser particles and were decanted from their sediments before being submitted to analysis. In other cases filter paper was used to separate visibly foul matter from the water, and the filtrate was sent for analysis. Filter paper will not remove from water thus befouled the finer particulate matter, that in which the dangerous quality of the water probably resides. It was found that filtrates thus prepared, when compared with equally polluted waters that had been merely decanted from their sediments, yielded a smaller quantity of albuminoid ammonia; less on the average in the proportion of 10 to 7.—If anyone should think of any filtration as customarily conducted, that it may be expected to affect to a material degree the ability of specifically polluted water to produce specific disease, he must be unacquainted with the observations made in relation to the notable epidemic of enteric fever at Lausen in Switzerland in 1872.

† Supplement to Board's Ninth Annual Report, containing report of Medical Officer on the year 1879.

most dangerous material; and the indication of that befoulment, when expressed by the chemist, in terms of albuminoid ammonia, is the figure ·014 part per million parts of the water. Wherefore it is not permissible to accept the doctrines which have been formulated from the amount of albuminoid ammonia present in an otherwise unknown water. Polluting material, potent for harm, may be present in a water "yielding from "·00 up to ·05 parts of albuminoid ammonia per million," without removing it from the rank of waters of "extraordinary organic purity"; and we assuredly have no evidence, in the case of an unknown water showing from ·05 to ·10 parts of albuminoid ammonia per million, that it is "safe organically."

is consistent with comparative "purity" of water.

The lesson is taught afresh and significantly by Dr. Cory's report that while we must ever be on the watch for the indications that chemistry affords of contaminating matters gaining access to our waters, we must (at any rate until other methods of recognition are discovered), go beyond the laboratory for evidence of any drinking water being free from dangerous organic pollution. Unless the chemist is well acquainted with the origin and liabilities of the water he is examining, he is not justified in speaking of a water as "safe" or "wholesome," if it contain any trace whatever of organic matter; hardly indeed even if it contain absolutely none of such matter appreciable by his very delicate methods. The chemist can, in brief, tell us of impurity and hazard, but not of purity and safety. For information about these we must go, with the aid of what the chemist has been able to teach us, in search of the conditions surrounding water sources and affecting water services.

Researches into mutations of micro-organisms. Dr. Klein.

Dr. Klein has been engaged on an investigation into the relation of pathogenic to septic bacteria, with the result of adding to the probability that these micro-organisms are either not transmutable the one into the other kind, or are, at any rate, less readily transmuted than has been supposed.

Cultivating disease-bacilli in organic liquids and in gelatiniform organic substances prepared in his laboratory, Dr. Klein has found (as Dr. Koch found before him) appearance of changes, both in form and potency, to be undergone by the bacilli. Of some such apparent changes, Dr. Klein has shown that they were really due to the presence, in the cultivation-material, of a new bacillus accidentally introduced; and he points out that a mere overgrowth of the one bacillus by the other, as corn may be overgrown by weeds, is not to be confounded with a true change in the original organism or in its own inherent qualities.

The specific bacillus of a disease, as illustrated by the case of anthrax, has indeed in the course of its own proper life times and occasions of remarkable change in its powers. These are more particularly two:—

(1.) Dr. Klein finds reason for attaching greater importance than had before been assigned to the occurrence of spore-

formation in the bacillus. In inoculation experiments with a material containing anthrax bacilli, it is found that an altogether new virulence is acquired by the material as a consequence of the formation of spores in its bacilli; and Dr. Klein in demonstrating this fact is able to show, by some important new observations, that the formation or non-formation of spores in the bacilli is largely a matter of definable circumstance and condition. His results herein appear to indicate some new departures in the investigation of the whole subject.

(2.) After several weeks of growth of anthrax bacillus in any given specimen of Dr. Klein's cultivation-material the anthrax bacillus undergoes degeneration; from exhaustion, it would appear, of the pabulum on which it had lived. The change affects more and more threads of the bacillus, and goes on to affect the appearance of the preparation as well under the naked eye as under the microscope. As this degeneration proceeds, the material ceases to injure with certainty the animals into which it is inoculated. But if any effect at all be produced by inoculation of the degenerating material, it is just the same injury or the same fatal result as would have been produced on the animal by inoculation of the material before degeneration processes had begun in it. The change is in the number of active bacilli, not in the potency of the several bacilli.

The foregoing changes are those occurring in the course of one cultivation, and in Dr. Klein's observations they are found to occur in exactly the same manner in each of several successive cultivations made by inoculating successive samples of his cultivation-material, each from its predecessor.

Through ten, twenty, or thirty cultivations extending over many weeks, Dr. Klein has grown the bacilli of anthrax at temperatures ranging between 22° and 42° C. under conditions especially arranged for securing accuracy and intelligibility of result; and (similar stages of each cultivation being taken for comparison) each successive cultivation has shown him, on the rodent animals that he has made the subject of experiment, results identical with the cultivation that preceded it. In the course of these successive cultivations, made after the manner that M. Pasteur and others believe to produce attenuation of virus, Dr. Klein has not been able to discover any indication of such a loss of intensity as shall allow of the material of a late cultivation being put into the body of an animal without killing it or doing it serious injury, but with the result of thenceforth protecting it against death by anthrax when the poison of the original disease is inoculated into the animal. Thus Dr. Klein without throwing doubt on the discovery by Pasteur of a material protective against fatal anthrax in the sheep, would guard his reader against generalizing from Pasteur's experience, and against inferring from it that an "attenuated" virus can be had by the recognized method of successive cultivations in organic liquids at 42° C. There is something more than this wanted

for the production of Pasteur's anthrax vaccine, and the conditions for it have not ceased from the Pasteur laboratory.

In my report on the proceedings of the year [illegible] Mr. Spear's inquiries into the [illegible] shire), and the evidence accumulating [illegible] identical with the anthrax of cattle. In supplement to the evidence, I now present a report by Dr. Sheridan Delepine, a minute account of the anatomy and pathology of the [illegible] results of experimental inoculations in animals accompanied by microscopical drawings. The report is a supplement of earlier observations which Dr. Sheridan Delepine made for Mr. Spear's report of last year.

In the course of his investigation into the pathology of this form of anthrax in the human subject Dr. Sheridan Delepine discusses the anatomical indications in which the constitutional disease is set up by local inoculation of the virus into the surface of the skin-wound, and personally he accepts the conclusion that in the human subject this is the usual channel through which the poison enters the body.

Our recognition during recent years of minute vegetable organisms having intimate concern in the processes of putrefaction and of infection with the increasing knowledge that we are gaining respecting the nature of the ferment is raising in the hope that the means of controlling these processes may before long become better understood, and that in a similar manner we may obtain an insight into the conditions for effecting disinfection; that we may be longer be presented with the "futile certainty of vague chemical cleanings and powderings," of which my predecessor wrote with well-deserved scorn eight years ago. Study of the chemical results [illegible] observed bacterial changes has hardly yet been begun in England, and it has been by way of basis for such a study that I had, in 1881, the Board's authority to obtain from Mr. Victor Horsley, of University College, a report on the present state of knowledge concerning the physiological relations of some bacteria; a report which should consider the relation of the production and development of such bacteria: first, to the disintegration of proteids, and, secondly, to the vital processes, normal and abnormal, of the animal body, together with an account of what was known respecting the way in which these relations are modified by temperature and [illegible] conditions. These objects have been in a measure fulfilled in Mr. Horsley's report (Appendix B. No. 4), where an account is given, on the one hand, of the life-history of septic bacteria and [illegible] hand, of the chemical poison which appears to be [illegible] their vital activity. The report is amplified by [illegible] bibliography.

Dr. Thudichum is approaching to a close [illegible] the Chemistry of the Brain. In the present [illegible]

MEDICAL OFFICER'S REPORT.

B. No. 5) he makes further examination of some substances which had previously been recognized, and demonstrates some new compounds and reactions. He has made progress with the quantitative analysis of the human brain, and tabulates some 130 data respecting the chemical components of the several parts of the encephalon.

I have the honour to be,
Sir,
Your obedient servant,

GEORGE BUCHANAN.

June, 1882.

APPENDICES.

APPENDIX A.

No. 1.

DIGEST of the VACCINATION OFFICERS' RETURNS, with regard to CHILDREN whose BIRTHS were registered in the Year 1879.

The following is the eighth annual return under the Vaccination Act, 1871. Of 880,222 births returned to the Board by the several Vaccination Officers in England and Wales as registered during the year 1879, the number which at the time the return was made had been registered as successfully vaccinated was 756,835 (being 86·0 per cent. of the whole), and the number registered as having died before they could be vaccinated was 78,478 (or 8·9 per cent. of the whole). Of the remaining 44,909 children, 742 (or 0·084 per cent. of the whole) had been registered as insusceptible of vaccination; 26 (or 0·003 per cent.) as having contracted small-pox before they could be vaccinated; 6,670 (or 0·76 per cent.) as having their vaccination postponed by medical certificate, leaving 37,471 (or 4·3 per cent.) as "removed," "not to be traced," or otherwise unaccounted for. If from the 880,222 births returned by these Officers, deduction of the deaths without vaccination be first made, it appears that of the surviving 801,744 children, there were registered at the time of the return 94·4 per cent. as successfully vaccinated; 0·096 per cent. as either insusceptible of vaccination, or as having had small-pox; and 0·83 per cent. as under medical certificate of postponement; leaving 4·7 per cent. as at that time still unaccounted for as regards vaccination.

Of the 37,471 cases which this last per-centage represents, the majority were children who could not be found by the Vaccination Officers, usually because of the removal of the parents from the place of birth. The remaining cases in the last column (with the exception of a certain number in which vaccination had really been performed successfully, but which could not be registered as vaccinated on account of the legal certificate of vaccination not having been received by the Vaccination Officer) were cases which at the time of the return were still unvaccinated in the union or district of birth.

The results continue to be less complete in the metropolis than in the rest of the Kingdom, and the proportion of cases unaccounted for in the metropolitan returns for 1879, is 7·8 per cent.

App. A. No. 1.
Digest of Vaccination Officers' Returns.

The percentage in the rest of the kingdom, which was 4·3 in 1878, was 4·5 in 1879. Of the registered births of the eight years 1872–79, the proportion not finally accounted for in regard to vaccination in each year respectively has been in the metropolis 8·8, 8·7, 8·8, 9·3, 6·5, 7·1, 7·1, and 7·8 per cent., while in the rest of the kingdom it has been only 4·5, 4·2, 4·1, 3·8, 4·0, 4·1, 4·3, and 4·5 per cent. In 1879 the proportion of cases unaccounted for, after deduction of the postponed cases, in the metropolis and in the rest of the kingdom, was 7·0 and 3·8 per cent. of births respectively.

Returns, 1879.

	Returns, 1879.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Dead. Unvaccinated.	Vaccination postponed.	Remaining.	Per-centage of Children not finally accounted for, including Cases postponed.
ENGLAND & WALES -	880,222	756,835	742	26	76,478	6,670	37,471	5·0
Ditto excluding Metropolitan Unions.	748,653	647,155	490	9	67,081	5,732	28,186	4·5
Metropolitan Unions	131,569	109,680	252	17	11,397	938	9,285	7·8
Counties.								
Bedford - - -	4,911	4,277	3	—	499	22	110	2·7
Berks - - -	7,885	7,040	8	—	589	73	175	3·1
Bucks - - -	5,183	4,551	3	—	497	26	86	2·3
Cambridge - - -	5,910	5,201	4	—	536	45	124	2·9
Chester - - -	20,286	18,064	19	—	1,701	81	421	2·5
Cornwall - - -	9,439	8,282	4	—	888	94	171	2·6
Cumberland - - -	8,672	7,635	—	—	759	68	210	3·2
Derby - - -	13,983	11,820	10	—	1,529	69	755	5·9
Devon - - -	18,181	16,156	15	—	1,361	230	419	3·6
Dorset - - -	5,493	4,895	2	—	414	61	121	3·3
Durham - - -	33,637	28,203	6	—	3,320	292	1,816	6·3
Essex - - -	17,646	15,687	9	—	1,294	85	571	3·7
Gloucester - - -	16,833	14,677	12	—	1,404	116	624	4·4
Hereford - - -	3,400	2,904	—	—	324	34	138	5·1
Herts - - -	7,382	6,079	11	—	553	31	108	1·9
Huntingdon - -	1,630	1,483	—	—	112	7	28	2·1
Kent (extra-metropolitan)	22,573	20,156	19	1	1,707	192	498	3·1
Lancaster - -	127,759	109,826	78	1	11,972	870	5,012	4·6
Leicester - - -	11,718	9,110	4	—	1,409	41	1,154	10·2
Lincoln - - -	15,039	12,589	7	1	1,492	183	767	6·3
Middlesex (ex.-metropol.)	10,491	9,151	17	—	817	73	433	4·8
Monmouth - -	8,035	7,101	2	—	675	48	209	3·2
Norfolk - - -	13,323	11,644	12	—	1,318	96	253	2·6
Northampton - -	9,362	7,863	3	—	905	88	503	6·2
Northumberland - -	15,329	13,368	21	—	1,306	173	401	3·7
Nottingham - -	15,254	12,665	12	—	1,631	151	791	6·2
Oxford - - -	5,726	4,859	3	—	524	56	285	6·0
Rutland - - -	747	655	1	—	59	3	29	4·3
Salop - - -	7,927	7,020	3	—	683	71	150	2·8
Somerset - - -	15,366	13,604	6	5	1,274	168	307	3·1
Southampton - -	17,734	15,787	24	—	1,269	209	445	3·7
Stafford - - -	32,770	28,441	17	—	3,135	131	1,046	3·6
Suffolk - - -	11,421	10,089	7	—	998	91	226	2·8
Surrey (extra metropol.) -	13,547	11,869	19	—	975	150	494	4·8
Sussex - - -	14,507	12,758	13	—	1,089	187	550	5·0
Warwick - - -	25,754	22,221	27	—	2,285	97	1,124	4·7
Westmoreland - -	1,937	1,777	2	—	129	16	13	1·5
Wilts - - -	7,813	7,042	1	—	587	68	115	2·3
Worcester - - -	19,155	16,532	8	—	1,829	101	685	4·1
York, East Riding -	12,364	10,521	11	—	1,135	93	604	5·6
York, North Riding -	11,370	9,939	8	—	1,014	91	318	3·6
York, West Riding -	76,244	63,633	50	—	7,282	572	4,707	6·9
Wales.								
Anglesey - - -	985	864	—	—	89	3	29	3·2
Brecknock - -	1,748	1,512	—	—	175	17	44	3·5
Cardigan - - -	2,160	1,944	—	—	150	20	46	3·1
Carmarthen - -	4,282	3,870	—	—	356	10	46	1·3
Carnarvon - - -	3,862	3,577	3	—	358	34	90	3·2
Denbigh - - -	2,688	2,379	—	—	238	29	42	2·6
Flint - - -	2,842	2,505	1	—	252	21	63	3·0
Glamorgan - -	18,536	16,206	4	1	1,639	110	576	3·7
Merioneth - -	2,254	1,945	—	—	221	35	53	3·9
Montgomery - -	2,357	1,950	—	—	217	46	134	7·6
Pembroke - -	2,586	2,280	—	—	219	42	55	3·7
Radnor - - -	567	485	—	—	56	12	13	4·2

APP. A. No. 1.

Digest of Vaccination Officers' Returns.

METROPOLITAN UNIONS.	RETURNS, 1879.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Dead. Unvaccinated.	Vaccination postponed.	Remaining.	Per-centage of Children not finally accounted for, including Cases postponed.
Bethnal Green - -	5,140	4,274	1	—	452	34	379	8·0
Camberwell - - -	6,278	5,055	7	—	588	57	571	10·0
Chelsea - - -	3,043	2,531	7	—	290	—	215	7·1
Fulham - - -	3,903	3,294	13	1	318	20	257	7·1
George, St., Hanover Sq. -	3,989	3,185	20	4	396	—	384	9·6
George, St., in the East -	1,926	1,595	1	—	186	7	137	7·5
Giles and George, S.S. -	1,607	1,289	—	—	124	13	182	12·1
Greenwich - - -	4,510	3,846	19	6	327	10	302	6·9
Hackney - - -	6,207	5,278	16	2	485	34	392	6·9
Hampstead - - -	1,019	891	3	—	88	8	29	3·6
Holborn - - -	5,757	4,817	6	—	517	19	398	7·2
Islington - - -	9,723	8,056	11	—	749	130	775	9·3
Kensington - - -	4,662	3,999	27	2	412	10	212	4·8
Lambeth - - -	9,090	6,919	28	1	840	63	1,239	14·3
Lewisham - - -	2,085	1,864	2	—	137	5	57	3·0
London, City - -	1,255	1,061	—	—	106	9	79	7·0
Marylebone - - -	4,907	3,961	3	—	561	86	296	7·8
Mile End Old Town -	4,329	3,606	5	—	395	34	289	7·5
Olave, St. - - -	5,484	4,827	9	—	424	16	208	4·1
Paddington - - -	2,847	2,410	12	—	202	18	205	7·8
Pancras, St. - -	8,048	6,752	14	—	652	44	586	7·8
Poplar - - -	6,274	5,521	21	—	476	16	240	4·1
Saviour, St. - -	7,542	6,342	—	—	675	118	407	7·0
Shoreditch - - -	5,110	3,990	2	—	466	49	603	13·8
Stepney - - -	2,284	1,833	3	—	267	—	181	7·9
Strand - - -	936	762	2	—	101	6	65	7.6
Wandsworth and Clapham	6,732	5,824	13	1	526	67	301	5·5
Westminster - -	1,296	1,104	3	—	124	8	57	5·0
Whitechapel - -	2,735	2,430	1	—	232	2	70	2·6
Woolwich - - -	2,851	2,362	3	—	261	56	169	7·9
	131,569	109,680	252	17	11,397	938	9,285	7·3

—	Returns, 1879.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Dead. Unvaccinated.	Vaccination postponed.	Remaining.	Percentage of Children not finally accounted for, including Cases postponed.
BEDFORD.								
Ampthill	531	490	1	—	21	1	8	1·7
Bedford	1,231	1,090	—	—	111	1	29	2·4
Biggleswade	892	795	1	—	86	2	9	1·2
Leighton Buzzard	616	550	2	—	43	7	14	3·4
Luton	1,357	1,123	—	—	173	10	46	4·1
Woburn	284	254	—	—	25	1	4	1·8
BERKS.								
Abingdon	715	636	—	—	62	—	15	2·1
Bradfield	567	513	—	—	39	10	5	2·6
Cookham	515	460	—	—	37	—	18	3·5
Easthampstead	395	362	1	—	17	—	5	1·3
Farringdon	460	421	1	—	26	4	8	2·6
Hungerford	612	562	—	—	41	6	3	1·5
Newbury	632	553	2	—	44	12	21	5·2
Reading	1,489	1,330	1	—	123	17	18	2·4
Wallingford	442	395	—	—	43	5	9	3·2
Wantage	546	496	—	—	44	2	6	1·5
Windsor	865	766	2	—	59	2	45	5·2
Wokingham	655	552	1	—	63	16	24	6·0
BUCKS.								
Amersham	615	552	—	—	55	3	5	1·3
Aylesbury	805	702	—	—	76	12	16	2·5
Buckingham	371	323	—	—	29	—	19	5·1
Eton	513	736	1	—	64	4	8	1·5
Newport Pagnell	863	753	1	—	93	1	15	1·9
Winslow	247	223	1	—	19	1	4	2·0
Wycombe	1,419	1,263	—	—	132	5	19	1·7
CAMBRIDGE.								
Cambridge	933	813	3	—	85	13	18	2·3
Caxton and Arrington	343	306	—	—	35	—	2	0·6
Chesterton	921	825	—	—	76	5	21	2·8
Ely	736	613	1	—	83	4	33	5·7
Linton	400	365	—	—	22	8	5	3·3
Newmarket	866	791	—	—	61	5	9	1·6
North Witchford	501	453	—	—	39	2	7	1·8
Whittlesey	213	185	—	—	22	1	5	2·8
Wisbech	996	850	—	—	120	7	19	2·6
CHESTER.								
Altrincham	1,788	1,683	1	—	122	7	25	1·8
Birkenhead	3,666	3,330	6	—	285	8	30	1·8
Chester	1,532	1,394	1	—	143	10	4	0·9
Congleton	1,213	1,078	—	—	118	13	10	1·9
Macclesfield	2,006	1,770	3	—	169	5	61	3·3
Nantwich	2,105	1,863	3	—	153	11	76	4·1
Northwich	1,610	1,432	1	—	159	4	14	1·1
Runcorn	1,271	1,153	—	—	103	2	13	1·2
Stockport	3,941	3,396	3	—	383	17	135	3·9
Tarvin	317	288	1	—	20	1	7	2·5
Tarrall	813	736	—	—	57	3	17	2·5

App. A. No. 1.

Digest of Vaccination Officers' Returns.

	Returns, 1879.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Dead. Unvaccinated.	Vaccination postponed.	Remaining.	Per-centage of Children not finally accounted for, including Cases postponed.
CORNWALL.								
Austell, St.	986	855	1	—	104	9	18	2·7
Bodmin	546	503	1	—	38	1	3	0·7
Camelford	263	230	—	—	26	1	6	2·7
Columb, St. Major	486	445	—	—	37	1	3	0·8
Falmouth	716	625	1	—	66	6	18	3·4
German's, St.	466	423	—	—	33	4	1	1·1
Helston	665	568	—	—	68	12	17	4·4
Launceston	469	424	—	—	37	4	4	1·7
Liskeard	831	753	2	—	54	5	17	2·6
Penzance	1,466	1,279	—	—	144	16	27	3·9
Redruth	1,360	1,146	—	—	173	12	29	3·0
Stratton	239	214	—	—	16	6	3	3·8
Truro	946	812	—	—	92	17	25	4·4
CUMBERLAND.								
Alston-with-Garrigill	137	128	—	—	8	—	1	0·7
Bootle	474	442	—	—	23	2	7	1·9
Brampton	321	289	—	—	29	2	1	0·9
Carlisle	1,762	1,575	—	—	161	11	22	1·9
Cockermouth	2,000	1,702	—	—	201	21	76	4·9
Longtown	241	218	—	—	20	2	1	1·2
Penrith	727	658	—	—	64	2	3	0·7
Whitehaven	2,268	1,974	—	—	190	21	83	4·6
Wigton	735	649	—	—	63	7	16	3·1
DERBY.								
Ashbourne	610	544	—	—	44	2	20	3·6
Bakewell	891	750	—	—	95	20	26	5·2
Belper	2,068	1,862	2	—	176	1	27	1·4
Chapel-en-le-Frith	673	597	1	—	50	6	19	3·7
Chesterfield	4,085	3,524	1	—	417	23	120	3·5
Derby	2,949	2,220	4	—	286	4	435	14·9
Glossop	705	576	—	—	98	5	26	4·4
Hayfield	438	389	—	—	33	2	14	3·7
Shardlow	1,564	1,358	2	—	130	6	68	4·7
DEVON.								
Axminster	557	503	—	—	40	3	11	2·5
Barnstaple	1,037	928	—	—	73	16	20	3·5
Bideford	579	526	—	—	44	3	6	1·6
Crediton	536	496	—	—	32	4	4	1·5
East Stonehouse	616	549	—	—	39	5	23	4·5
Exeter	1,121	954	—	—	120	7	40	4·2
Holsworthy	290	259	—	—	19	1	11	4·1
Honiton	667	619	—	—	35	6	7	1·9
Kingsbridge	564	520	1	—	36	2	5	1·2
Newton Abbot	2,086	1,895	2	—	159	9	21	1·4
Okehampton	552	502	—	—	38	7	5	2·2
Plymouth	2,315	1,921	5	—	215	87	87	7·5
Plympton St. Mary	737	634	—	—	55	24	24	6·5
South Molton	496	453	2	—	33	3	5	1·6
Stoke Damerel	1,453	1,270	—	—	110	9	64	5·4
Tavistock	761	705	—	—	44	2	10	1·6
Thomas, St.	1,479	1,304	—	—	113	21	41	4·2
Tiverton	778	697	2	—	52	12	15	3·5
Torrington	450	396	1	—	35	4	12	3·6
Totnes	1,107	1,023	2	—	69	5	8	1·2

App. A. No. 1.

Digest of Vaccination Officers Returns.

	Returns, 1879.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Dead. Unvaccinated.	Vaccination postponed.	Remaining.	Per-centage of Children not finally accounted for, including Cases postponed.
DORSET.								
Beaminster	332	288	1	—	32	3	9	3·6
Blandford	372	339	1	—	21	10	11	5·6
Bridport	461	410	—	—	37	7	7	3·0
Cerne	214	189	—	—	21	2	2	1·9
Dorchester	537	482	—	—	50	—	5	0·9
Poole	642	573	—	—	53	4	13	2·6
Shaftesbury	387	348	—	—	23	7	9	4·1
Sherborne	381	344	—	—	24	4	9	3·4
Sturminster	275	254	—	—	18	—	3	1·1
Wareham and Purbeck	514	471	—	—	35	1	7	1·6
Weymouth	866	764	1	—	71	14	36	5·6
Wimborne and Cranborne	462	444	—	—	29	9	10	3·9
DURHAM.								
Auckland	3,002	2,806	—	—	340	13	141	5·9
Chester-le-Street	1,711	1,508	—	—	173	3	27	1·8
Darlington	1,838	1,647	2	—	166	13	100	6·9
Durham	2,264	1,964	2	—	284	36	78	4·8
Easington	1,550	1,390	—	—	144	11	105	6·8
Gateshead	4,111	3,293	—	—	434	12	372	9·3
Hartlepool	1,900	1,663	—	—	190	25	22	2·5
Houghton-le-Spring	1,439	1,252	—	—	143	7	37	3·1
Lanchester	2,204	1,954	—	—	180	16	45	2·8
Sedgefield	636	539	—	—	55	9	33	6·6
South Shields	4,138	3,396	—	—	402	54	286	8·2
Stockton	2,015	1,680	—	—	158	16	161	8·7
Sunderland	5,314	4,355	2	—	511	70	376	8·4
Teesdale	634	556	—	—	57	1	20	3·3
Weardale	601	508	—	—	74	6	13	3·2
ESSEX.								
Billericay	506	449	—	—	42	—	15	3·0
Braintree	809	697	—	—	60	5	47	6·4
Chelmsford	989	903	—	—	64	12	10	2·2
Colchester	998	796	—	—	68	4	30	3·8
Dunmow	534	491	—	—	36	4	3	1·3
Epping	653	565	—	—	49	7	13	3·0
Halstead	478	417	1	—	42	5	13	3·8
Lexden and Winstree	690	645	—	—	37	3	5	1·2
Maldon	738	659	—	—	48	4	27	4·2
Ongar	305	258	—	—	32	5	10	4·9
Orsett	579	533	1	—	34	3	8	1·9
Rochford	802	715	—	—	65	1	21	2·7
Romford	1,378	1,128	—	—	92	14	50	5·9
Saffron Walden	593	530	1	—	49	4	9	2·2
Tendring	860	764	1	—	58	7	30	4·3
West Ham	6,964	6,143	5	—	518	7	281	4·1
GLOUCESTER.								
Barton Regis	5,818	5,158	3	—	466	12	179	3·3
Bristol	1,955	1,653	1	—	197	6	98	5·3
Cheltenham	1,422	1,143	—	—	100	48	131	13·6
Chipping Sodbury	533	473	—	—	39	8	13	3·9
Cirencester	616	541	—	—	48	4	23	4·4
Dursley	376	331	3	—	35	3	4	1·9
Gloucester	1,532	1,347	2	—	131	9	43	3·4
Newent	352	306	—	—	35	2	9	3·1
Northleach	280	251	—	—	18	1	15	5·7

App. A. No. 1.

Digest of Vaccination Officers' Returns.

	Returns, 1879.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Dead. Unvaccinated.	Vaccination postponed.	Remaining.	Per-centage of Children not finally accounted for, including Cases postponed.
GLOUCESTER—*cont.*								
Stow-on-the-Wold	251	223	1	—	16	2	10	4·8
Stroud	1,296	1,145	2	—	120	6	23	2·2
Tetbury	157	142	—	—	6	5	4	5·7
Tewkesbury	374	324	1	—	36	2	12	3·7
Thornbury	549	496	—	—	44	3	6	1·6
Westbury-on-Severn	830	703	1	—	76	3	47	6·0
Wheatenhurst	220	209	—	—	9	—	2	0·9
Winchcomb	272	232	—	—	33	2	5	2·6
HEREFORD.								
Bromyard	349	292	—	—	38	8	11	5·4
Dore	275	233	—	—	24	6	12	6·5
Hereford	1,000	837	—	—	100	5	38	4·3
Kington	357	316	—	—	23	2	16	5·0
Ledbury	318	280	—	—	25	1	12	4·1
Leominster	372	303	—	—	40	5	24	7·8
Ross	486	408	—	—	56	4	18	4·5
Weobley	243	215	—	—	18	3	7	4·1
HERTS.								
Albans, St.	784	704	1	—	59	4	16	2·6
Barnet	874	783	2	—	65	6	18	3·7
Berkhampstead	502	446	—	—	40	—	14	2·8
Bishop's Stortford	731	651	—	—	54	4	12	2·2
Buntingford	172	158	—	—	13	—	1	0·6
Hatfield	215	195	1	—	13	4	2	2·8
Hemel Hempstead	487	429	—	—	44	3	11	2·9
Hertford	476	436	1	—	30	—	9	1·9
Hitchin	980	896	—	—	76	2	6	0·9
Royston	637	564	4	—	54	4	1	0·8
Ware	581	530	—	—	44	1	6	1·2
Watford	886	810	2	—	60	3	11	1·6
Welwyn	77	75	—	—	1	—	1	1·3
HUNTINGDON.								
Huntingdon	620	566	—	—	41	2	11	2·1
Ives, St.	491	445	—	—	33	3	10	2·6
Neots, St.	519	472	—	—	38	2	7	1·7
KENT (Extra-Metropolitan).								
Ashford, East	444	410	—	—	23	2	9	2·5
Ashford, West	569	510	—	—	41	5	13	3·2
Blean	594	543	—	—	41	1	9	1·7
Bridge	358	317	—	—	25	2	14	4·5
Bromley	1,437	1,258	2	—	138	15	24	2·7
Canterbury	523	460	—	—	45	—	18	3·4
Cranbrook	385	337	—	—	38	5	5	2·6
Dartford	1,672	1,506	3	—	120	11	32	2·6
Dover	1,192	952	1	—	80	35	124	13·3
Eastry	825	735	—	—	58	12	20	3·9
Elham	1,064	962	—	—	92	5	15	1·9
Faversham	903	831	1	—	64	3	4	0·8
Gravesend and Milton	698	634	—	—	38	2	24	3·7
Hollingbourn	436	396	—	—	35	2	3	1·1
Hoo	123	104	—	—	14	—	5	4·1
Maidstone	1,498	1,320	—	—	120	16	42	3·9

App. A. No. 1.

Digest of Vaccination Officers' Returns.

	Returns, 1879.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Dead. Unvaccinated.	Vaccination postponed.	Remaining.	Per-centage of Children not finally accounted for, including Cases postponed.
KENT (Extra-Metropolitan)—*cont.*								
Malling	865	789	1	—	75	10	10	2·3
Medway	2,092	1,898	—	—	167	17	14	1·5
Milton	912	832	—	—	66	4	10	1·5
North Aylesford	943	864	—	—	69	1	9	1·1
Romney Marsh	173	158	1	—	14	—	—	0·0
Sevenoaks	831	742	5	1	63	3	17	2·4
Sheppey	604	550	—	—	37	5	12	2·8
Tenterden	358	327	—	—	22	7	2	2·5
Thanet, I. of	1,496	1,375	3	—	106	14	26	2·8
Tonbridge	1,624	1,456	2	—	114	15	37	3·2
LANCASTER.								
Ashton-under-Lyne	5,392	4,671	1	—	531	37	152	3·5
Barrow-in-Furness	1,726	1,529	—	—	138	5	54	3·4
Barton-upon-Irwell	2,356	2,046	2	—	184	16	110	5·3
Blackburn	6,278	5,646	1	—	531	14	86	1·6
Bolton	6,861	6,256	3	—	544	1	57	0·8
Burnley	4,231	3,569	—	—	477	24	131	3·7
Bury	4,446	3,985	2	—	416	20	81	2·3
Chorley	1,777	1,508	—	—	189	4	76	4·5
Chorlton	9,275	7,526	4	—	978	117	650	8·3
Clitheroe	748	669	—	—	57	5	17	2·9
Fylde, The	1,385	1,179	—	—	116	2	38	3·0
Garstang	404	368	—	—	20	2	14	4·0
Haslingden	3,333	3,043	1	—	257	5	26	0·9
Lancaster	1,341	1,188	—	—	105	14	34	3·6
Leigh	2,237	1,991	2	—	204	5	35	1·8
Liverpool	7,543	6,358	8	1	839	6	331	4·5
Lunesdale	206	187	—	—	16	2	1	1·5
Manchester	5,963	4,907	4	—	609	104	359	7·7
Oldham	5,817	4,813	2	—	564	70	369	7·5
Ormskirk	2,732	2,483	3	—	218	10	68	2·9
Prescot	4,817	4,060	3	—	436	36	282	6·2
Preston	4,521	3,790	5	—	506	19	201	4·9
Prestwich	4,285	3,598	1	—	380	2	304	7·1
Rochdale	3,891	3,338	4	—	369	29	151	4·6
Salford	7,306	6,064	4	—	817	71	350	5·8
Todmorden	1,050	909	—	—	101	—	40	3·8
Toxteth Park	4,285	3,648	8	—	336	26	267	6·8
Ulverstone	1,587	1,414	—	—	110	27	36	4·0
Warrington	2,770	2,337	2	—	275	33	123	5·6
West Derby	13,208	11,514	15	—	1,060	121	484	4·6
Wigan	6,020	5,283	3	—	586	43	105	2·5
LEICESTER.								
Ashby-de-la-Zouch	1,208	1,039	—	—	113	3	53	4·6
Barrow-on-Soar	1,065	834	1	—	127	4	99	9·7
Blaby	295	249	—	—	25	1	20	7·1
Hinckley	753	639	—	—	78	5	31	4·8
Lutterworth	651	572	—	—	71	—	8	1·2
Leicester	4,695	3,066	2	—	722	25	860	18·8
Loughborough	989	871	—	—	99	—	19	1·9
Lutterworth	351	332	1	—	23	—	5	1·4
Market Bosworth	504	451	—	—	45	2	6	1·6
Market Harborough	533	474	—	—	42	—	17	3·2
Melton Mowbray	674	573	—	—	64	1	36	5·5

App. A. No. 1.

Digest of Vaccination Officers' Returns.

	Returns, 1879.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Dead. Unvaccinated.	Vaccination postponed.	Remaining.	Per-centage of Children not finally accounted for, including Cases postponed.
LINCOLN.								
Boston	1,187	966	1	—	127	8	85	7·5
Bourn	605	505	1	—	65	6	28	2·6
Caistor	2,336	1,920	1	—	270	29	116	6·4
Gainsborough	1,022	835	2	—	98	18	69	8·5
Glanford Brigg	1,366	1,203	—	—	100	25	38	4·6
Grantham	1,109	969	—	—	101	7	32	3·5
Holbeach	642	542	—	—	65	6	29	5·3
Horncastle	635	560	—	—	53	3	19	3·5
Lincoln	2,196	1,675	—	1	254	38	228	12·1
Louth	1,053	890	2	—	110	22	29	4·1
Sleaford	791	710	—	—	60	5	16	2·7
Spalding	704	614	—	—	71	7	12	2·7
Spilsby	835	707	—	—	67	7	54	7·3
Stamford	558	493	—	—	51	2	12	2·5
MIDDLESEX (Extra-Metropolitan).								
Brentford	3,139	2,601	9	—	262	13	164	5·6
Edmonton	4,121	3,607	4	—	293	34	183	5·3
Hendon	1,086	1,483	4	—	131	6	62	4·9
Staines	740	637	—	—	64	17	22	3·5
Uxbridge	805	733	—	—	67	3	2	0·6
MONMOUTH.								
Abergavenny	800	733	—	—	55	3	9	1·5
Bedwellty	1,974	1,740	—	—	172	19	43	3·1
Chepstow	553	485	—	—	53	8	7	2·7
Monmouth	986	868	1	—	91	8	18	2·6
Newport	2,414	2,187	1	—	195	5	26	1·3
Pontypool	1,308	1,088	—	—	109	5	106	8·5
NORFOLK.								
Aylsham	523	451	—	—	55	2	15	3·1
Blofield	320	286	—	—	31	3	—	0·9
Depwade	660	553	3	—	73	4	27	4·7
Docking	486	419	—	—	56	—	11	2·3
Downham	610	526	1	—	71	—	12	2·3
Erpingham	589	524	2	—	44	12	7	3·2
Faith, St.	339	307	1	—	30	—	1	0·3
Flegg, East and West	326	277	—	—	44	2	3	1·5
Forehoe	341	297	—	—	29	—	15	4·4
Freebridge Lynn	388	342	—	—	29	7	10	4·4
Guiltcross	287	256	—	—	25	1	5	2·1
Henstead	314	284	—	—	22	4	4	2·5
King's Lynn	556	479	—	—	58	6	13	3·4
Loddon and Clavering	383	344	—	—	34	—	5	1·3
Mitford and Launditch	840	755	—	—	79	1	5	0·7
Norwich	2,871	2,529	1	—	297	4	40	1·5
Swaffham	399	326	—	—	46	20	7	6·8
Thetford	553	471	—	—	56	3	23	4·7
Smallburgh	439	392	2	—	33	1	11	2·5
Walsingham	550	478	—	—	56	6	10	2·9
Wayland	321	264	—	—	44	5	8	4·0
Yarmouth, Great	1,228	1,084	2	—	106	15	21	2·9

App. A. No. 1.

Digest of Vaccination Officers' Returns.

	Returns, 1879.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Dead. Unvaccinated.	Vaccination postponed.	Remaining.	Per-centage of Children not finally accounted for, including Cases postponed.
NORTHAMPTON.								
Brackley	379	303	—	—	49	11	16	7·1
Brixworth	344	314	—	—	20	1	9	2·9
Daventry	540	500	—	—	26	2	11	2·4
Hardingstone	387	352	—	—	23	2	10	3·1
Kettering	943	831	1	—	75	3	33	3·6
Northampton	2,346	1,726	—	—	269	27	327	15·1
Oundle	442	399	—	—	32	6	5	2·5
Peterborough	1,402	1,234	—	—	143	3	22	1·8
Potterspury	400	337	—	—	36	8	19	6·8
Thrapston	509	448	—	—	51	1	8	1·8
Towcester	379	335	1	—	34	2	7	2·4
Wellingborough	1,281	1,085	1	—	137	22	36	4·5
NORTHUMBERLAND.								
Alnwick	651	585	—	—	38	8	20	4·3
Belford	170	150	—	—	19	1	—	0·6
Bellingham	197	179	—	—	10	—	8	4·1
Berwick-on-Tweed	715	624	2	—	74	8	7	2·1
Castle Ward	654	570	4	—	63	2	15	2·6
Glendale	321	301	—	—	17	1	2	0·9
Haltwhistle	250	229	—	—	14	6	1	2·8
Hexham	1,151	1,003	—	—	88	11	49	5·2
Morpeth	1,314	1,120	4	—	147	10	33	3·3
Newcastle-on-Tyne	5,603	4,906	8	—	505	30	154	3·3
Rothbury	183	165	—	—	13	2	3	2·7
Tynemouth	4,130	3,536	3	—	378	94	109	4·9
NOTTINGHAM.								
Basford	4,610	3,907	3	—	503	29	168	4·3
Bingham	440	393	1	—	38	2	6	1·8
East Retford	750	684	—	—	47	1	18	2·5
Mansfield	1,736	1,441	—	—	189	13	93	6·1
Newark	966	839	5	—	85	7	30	3·8
Nottingham	5,051	3,894	2	—	616	92	447	10·7
Southwell	569	511	—	—	47	2	9	1·9
Worksop	1,133	1,000	1	—	106	5	20	2·2
OXFORD.								
Banbury	927	628	—	—	85	10	204	23·1
Bicester	443	371	—	—	49	16	7	5·2
Chipping Norton	584	528	1	—	44	3	8	1·9
Headington	868	779	—	—	75	2	10	1·4
Henley	611	550	—	—	40	9	13	3·4
Oxford	719	631	1	—	62	5	20	3·5
Thame	434	377	—	—	47	4	6	2·3
Witney	693	618	—	—	64	3	8	1·6
Woodstock	449	377	—	—	58	4	10	3·1
RUTLAND.								
Oakham	329	294	1	—	28	2	4	1·8
Uppingham	418	361	—	—	31	1	25	6·2

APP. A. No. 1.

Digest of Vaccination Officers' Returns.

	Returns, 1879.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Dead. Unvaccinated.	Vaccination postponed.	Remaining.	Per-centage of Children not finally accounted for, including Cases postponed.
SALOP.								
Atcham	1,381	1,216	1	—	121	19	24	3·1
Bridgnorth	399	353	—	—	31	—	15	3·8
Church Stretton	154	137	—	—	14	2	1	1·9
Cleobury Mortimer	255	231	—	—	17	2	5	2·7
Clun	299	254	—	—	29	2	14	5·3
Drayton	432	394	—	—	24	13	1	3·2
Ellesmere	389	353	—	—	26	2	8	2·6
Ludlow	566	452	1	—	78	10	25	6·2
Madeley	890	798	—	—	71	6	15	2·4
Newport	448	410	—	—	33	1	4	1·1
Oswestry	817	742	—	—	59	3	13	2·0
Shifnal	369	319	1	—	34	3	12	4·1
Wellington	902	799	—	—	95	2	6	0·9
Wem	279	252	—	—	20	4	3	2·5
Whitchurch	347	310	—	—	31	2	4	1·7
SOMERSET.								
Axbridge	1,177	1,055	—	—	75	16	31	4·0
Bath	1,872	1,657	1	5	143	9	57	3·5
Bedminster	2,533	2,158	2	—	283	45	45	3·1
Bridgwater	1,036	938	2	—	68	12	16	2·7
Chard	858	750	—	—	80	16	12	3·3
Clutton	831	767	—	—	58	—	6	0·7
Dulverton	165	150	—	—	11	1	3	2·4
Frome	731	652	—	—	56	2	21	3·1
Keynsham	899	794	—	—	78	4	23	3·0
Langport	465	422	—	—	35	2	6	1·7
Shepton Mallet	471	424	—	—	32	8	7	3·2
Taunton	995	886	2	—	91	7	9	1·6
Wellington	575	523	1	—	45	1	5	1·0
Wells	671	585	—	—	60	11	15	3·9
Williton	577	514	—	—	39	10	14	4·2
Wincanton	668	601	—	—	49	7	11	2·7
Yeovil	842	728	—	—	71	17	26	5·1
SOUTHAMPTON.								
Alresford	226	205	1	—	13	4	3	3·1
Alton	497	433	—	—	46	1	17	3·6
Alverstoke	727	665	1	—	51	1	9	1·4
Andover	538	488	1	—	33	2	14	3·0
Basingstoke	615	517	—	—	53	18	27	7·3
Catherington	73	64	—	—	4	2	3	6·8
Christchurch	860	734	1	—	72	20	33	6·2
Droxford	342	306	—	—	25	2	9	3·2
Fareham	468	430	—	—	24	5	9	3·0
Fordingbridge	186	177	—	—	7	—	2	1·1
Hartley Wintney	555	495	1	—	41	4	14	3·2
Havant	250	225	2	—	17	2	4	2·4
Hursley	76	73	—	—	3	—	—	0·0
Kingsclere	207	247	—	—	14	1	5	2·2
Lymington	362	312	—	—	27	12	11	6·4
New Forest	363	330	1	—	17	5	10	4·1
Petersfield	307	294	—	—	7	2	4	2·0
Portsea Island	4,187	3,823	6	—	298	9	51	1·4
Ringwood	184	171	—	—	9	1	3	2·2
Romsey	318	293	—	—	16	2	7	2·8
Southampton	1,761	1,518	1	—	137	29	76	6·0
South Stoneham	1,276	1,109	1	—	100	40	26	5·2
Stockbridge	197	184	—	—	12	1	—	0·5
Whitchurch	171	148	—	—	14	7	2	5·3
Wight, Isle of	2,125	1,828	5	—	159	36	97	6·3
Winchester, New	803	718	3	—	70	3	9	1·5

APP. A. No. 1.

Digest of Vaccination Officers' Returns.

	Returns, 1879.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-Pox.	Dead. Unvaccinated.	Vaccination postponed.	Remaining.	Per-centage of Children not finally accounted for, including Cases postponed.
STAFFORD.								
Wolstanton and Burslem	3,072	2,754	—	—	300	12	6	0·6
Burton-on-Trent	2,840	2,236	2	—	312	13	275	10·1
Cannock	1,452	1,361	1	—	100	—	30	2·1
Cheadle	790	715	—	—	58	2	15	2·2
Leek	1,090	935	—	—	111	7	27	3·1
Lichfield	1,363	1,205	1	—	105	11	40	3·7
Newcastle-under-Lyme	1,244	1,084	2	—	105	—	73	5·9
Tamworth	503	451	—	—	41	1	10	2·2
Stafford	1,023	907	—	—	88	10	23	3·2
Stoke-upon-Trent	4,202	3,567	2	—	452	17	164	4·3
Stone	941	837	—	—	84	2	18	2·1
Tettenhall	773	687	—	—	62	5	19	3·1
Uttoxeter	407	381	—	—	23	2	1	0·7
Walsall	3,397	2,888	8	—	356	15	130	4·3
West Bromwich	4,724	4,307	—	—	429	13	75	1·9
Wolverhampton	4,955	4,344	1	—	449	21	140	3·2
SUFFOLK.								
Aything	846	758	—	—	66	6	17	2·7
Bosmere and Claydon	483	430	—	—	39	2	12	2·9
Bury St. Edmunds	532	466	1	—	47	6	12	3·4
Cosford	524	455	—	—	57	2	10	2·3
Hartismere	512	458	—	—	43	2	12	2·7
Hoxne	382	339	1	—	34	1	7	2·1
Ipswich	1,700	1,450	2	—	157	46	45	5·4
Mildenhall	283	251	—	—	25	1	6	2·5
Stratford and Lothingland	1,392	1,236	—	—	125	1	30	2·2
Thingoe	651	574	—	—	62	2	13	2·3
Thredling	588	521	—	—	52	3	12	2·6
Wangford	339	297	1	—	35	—	6	1·8
Woodbridge	644	596	—	—	45	2	4	0·9
Woodbury	905	802	1	—	78	6	18	2·7
Wortham	468	445	—	—	31	2	10	2·5
Wrentham	454	402	—	—	43	3	1	0·9
Wyngfordbridge	698	625	1	—	56	9	8	2·4
SURREY (EXTRA-METROPOLITAN).								
Chertsey	773	669	2	—	55	17	29	6·0
Croydon	3,507	2,939	2	—	280	47	239	8·2
Dorking	419	384	1	—	25	1	8	2·1
Epsom	1,104	923	—	—	79	42	60	9·2
Farnham	1,474	1,317	2	—	92	2	51	4·3
Kingston	443	400	1	—	29	—	12	2·7
Guildford	1,168	1,024	1	—	105	16	16	2·8
Kingsbledon	458	446	—	—	23	1	18	3·9
Reigate	2,328	2,119	4	—	164	15	26	1·8
Richmond	868	789	2	—	59	6	12	2·1
Thetford	983	899	4	—	64	3	13	1·6
SUSSEX.								
Battle	468	420	2	—	32	3	11	3·0
Brighton	2,844	2,516	2	—	247	25	54	2·8
Chailey	271	234	—	—	27	3	7	3·7
Chichester	241	200	—	—	18	4	19	9·5
Cuckfield	661	575	1	—	51	7	27	5·1
Eastbourne	796	677	2	—	51	14	52	8·3
East Grinstead	590	516	—	—	59	3	12	2·5
Hove Preston	736	663	—	—	46	8	9	2·3

App. A. No. 1.

Digest of Vaccination Officers' Returns.

	Returns, 1879.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Dead. Unvaccinated.	Vaccination postponed.	Remaining.	Per-centage of Children not finally accounted for, including Cases postponed.
SUSSEX—*cont.*								
Hailsham	450	385	—	—	32	11	22	7·3
Hastings	1,389	1,135	—	—	110	40	104	10·4
Horsham	713	631	3	—	50	8	21	4·1
Lewes	317	261	—	—	31	8	17	7·0
Midhurst	417	376	—	—	31	4	6	2·4
Newhaven	271	242	—	—	19	2	8	3·7
Petworth	297	271	—	—	20	3	3	2·0
Rye	383	346	—	—	26	4	7	2·9
Steyning	1,399	1,179	2	—	104	9	105	8·2
Thakeham	275	248	—	—	17	7	3	3·6
Ticehurst	566	497	—	—	42	8	19	4·8
Uckfield	659	596	—	—	38	6	19	3·9
Westbourne	237	220	—	—	9	2	6	3·4
West Firle	71	62	—	—	6	2	1	4·2
Westhampnett	556	508	1	—	23	6	18	4·3
WARWICK.								
Alcester	613	527	—	—	64	7	15	3·6
Aston	8,363	7,015	5	—	728	30	585	7·4
Atherstone	520	457	2	—	42	4	15	3·7
Birmingham	9,516	8,262	13	—	856	27	359	4·1
Coventry	1,481	1,304	2	—	153	6	16	1·5
Foleshill	655	568	—	—	83	2	2	0·6
Meriden	278	252	—	—	21	2	3	1·8
Nuneaton	474	392	1	—	62	1	18	4·0
Rugby	855	765	2	—	58	5	25	3·3
Solihull	551	485	1	—	38	6	21	4·9
Southam	310	275	—	—	26	4	5	2·9
Stratford-on-Avon	715	622	1	—	58	1	33	4·8
Warwick	1,423	1,297	1	—	96	2	27	2·0
WESTMORELAND.								
East Ward	461	430	—	—	25	2	4	1·3
Kendal	1,255	1,148	2	—	83	13	9	1·8
West Ward	221	199	—	—	21	1	—	0·5
WILTS.								
Alderbury	781	707	—	—	59	6	9	1·9
Amesbury	231	208	—	—	18	2	3	2·2
Bradford	379	351	—	—	26	—	2	0·5
Calne	235	215	—	—	17	3	—	1·3
Chippenham	638	578	1	—	46	4	9	2·0
Cricklade and Wootton Bassett.	361	322	—	—	26	3	10	5·6
Devizes	671	611	—	—	44	8	8	2·4
Highworth and Swindon	1,343	1,182	—	—	108	24	29	3·9
Malmesbury	483	421	—	—	36	10	16	5·4
Marlborough	263	240	—	—	22	—	1	0·4
Melksham	574	521	—	—	46	3	4	1·2
Mere	231	210	—	—	19	1	1	0·9
Pewsey	358	317	—	—	31	—	10	2·5
Tisbury	252	230	—	—	18	—	4	1·6
Warminster	370	335	—	—	25	4	6	2·7
Westbury and Whorwelsdown.	326	301	—	—	23	—	2	0·6
Wilton	317	293	—	—	23	—	1	0·3

App. A. No. 1.

Digest of Vaccination Officers' Returns.

	Returns, 1879.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Dead. Unvaccinated.	Vaccination postponed.	Remaining.	Per-centage of Children not finally accounted for, including Cases postponed.
WORCESTER.								
Bromsgrove	1,073	941	1	—	106	8	17	2·3
Droitwich	777	689	—	—	70	3	15	2·3
Dudley	6,004	5,165	2	—	621	35	181	3·6
Evesham	480	419	—	—	42	4	15	4·0
Kidderminster	1,391	1,253	—	—	122	1	15	1·2
King's Norton	3,083	2,553	4	—	253	9	264	8·9
Martley	422	376	—	—	39	1	6	1·7
Pershore	402	363	—	—	34	—	5	1·2
Shipston-on-Stour	572	500	—	—	49	3	20	4·0
Stourbridge	3,133	2,750	—	—	306	7	70	2·5
Tenbury	244	203	—	—	25	8	8	6·6
Upton-on-Severn	501	435	—	—	51	5	10	3·0
Worcester	1,073	885	1	—	111	17	59	7·1
YORK, East Riding.								
Beverley	731	633	1	—	62	14	21	4·8
Bridlington	537	460	—	—	57	1	10	2·0
Driffield	668	569	—	—	81	10	8	2·7
Howden	365	350	—	—	37	3	5	2·0
Kingston-upon-Hull	2,911	2,510	4	—	265	15	117	4·5
Patrington	287	252	—	—	26	—	9	3·1
Pocklington	454	397	—	—	40	12	5	3·7
Sculcoates	3,598	3,115	4	—	304	22	153	4·9
Skirlaugh	328	284	1	—	32	2	4	1·9
York	2,460	1,942	1	—	231	14	272	11·6
YORK, North Riding.								
Aysgarth	165	141	—	—	19	—	5	3·0
Bedale	293	265	—	—	16	2	10	4·1
Easingwold	224	204	1	—	14	2	3	2·2
Guisborough	1,540	1,371	1	—	141	1	35	2·3
Helmsley Blackmoor	180	168	—	—	10	1	1	1·1
Kirkby Moorside	173	159	—	—	13	—	1	0·6
Leyburn	241	218	—	—	18	1	4	2·1
Malton	738	615	—	—	76	10	37	6·4
Middlesbrough	3,424	3,004	1	—	300	17	102	3·5
Northallerton	385	346	1	—	29	1	8	2·3
Pickering	376	317	—	—	42	3	14	4·5
Reeth	153	126	2	—	19	3	3	3·9
Richmond	409	363	—	—	34	8	4	2·9
Scarborough	1,375	1,162	1	—	129	31	52	6·0
Stokesley	380	337	—	—	38	—	5	1·3
Thirsk	417	375	—	—	31	1	10	2·6
Whitby	888	768	1	—	85	10	24	3·3
YORK. West Riding.								
Barnsley	3,280	2,769	2	—	327	38	144	5·5
Bramley	1,894	1,666	—	—	171	10	47	3·0
Bradford	6,246	5,082	3	—	682	4	475	7·7
Dewsbury, North	4,307	3,661	1	—	422	36	187	5·2
Dewsbury	5,433	4,177	3	—	545	63	645	13·0
Doncaster	1,823	1,590	2	—	196	5	30	1·9
Ecclesall Bierlow	4,076	3,507	3	—	342	36	188	5·5
Goole	714	637	—	—	60	1	16	2·4
Halifax	5,426	4,696	1	—	461	86	182	4·9

App. A. No. 1.

Digest of Vaccination Officers' Returns.

	Returns, 1879.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Dead. Unvaccinated.	Vaccination postponed.	Remaining.	Per-centage of Children not finally accounted for, including Cases postponed.
YORK, West Riding—*cont.*								
Hemsworth	349	306	—	—	26	—	17	4·9
Holbeck	983	883	—	—	92	7	21	2·3
Huddersfield	4,862	4,369	2	—	430	14	47	1·3
Hunslet	2,385	1,976	—	—	286	44	79	5·2
Keighley	1,970	479	1	—	177	20	1,293	66·6
Knaresborough	659	562	6	—	52	8	31	5·9
Leeds	6,914	6,135	2	—	650	13	114	1·8
Ouseburn, Great	361	338	—	—	20	1	2	0·8
Pateley Bridge	299	285	1	—	13	—	—	0·0
Penistone	621	543	1	—	53	7	17	3·9
Pontefract	2,056	1,712	—	—	194	6	144	7·3
Ripon	497	421	—	—	58	—	18	3·6
Rotherham	2,946	2,568	2	—	248	24	104	4·3
Saddleworth	756	657	—	—	69	2	28	4·0
Sedbergh	129	111	—	—	14	3	1	3·1
Selby	503	437	—	—	54	6	6	2·4
Settle	443	406	—	—	29	2	4	1·4
Sheffield	7,029	5,910	3	—	736	46	334	5·4
Skipton	1,235	987	13	—	132	31	72	8·3
Tadcaster	778	663	—	—	84	3	28	4·0
Thorne	521	446	—	—	54	3	18	4·0
Wakefield	3,576	2,821	1	—	308	6	240	7·3
Wetherby	441	365	1	—	37	10	28	8·6
Wharfedale	1,594	1,339	1	—	135	21	98	7·5
Wortley	1,338	1,147	1	—	125	16	49	4·9
ANGLESEY.								
Anglesey	416	359	—	—	46	1	11	2·6
Holyhead	569	505	—	—	43	3	18	3·7
BRECKNOCK.								
Brecknock	529	471	—	—	46	1	11	2·3
Builth	296	265	—	—	24	1	6	2·4
Crickhowell	603	503	—	—	68	18	19	5·3
Hay	320	273	—	—	37	2	8	3·1
CARDIGAN.								
Abercaeron	353	306	—	—	29	4	12	4·5
Aberystwith	724	658	—	—	42	5	19	3·3
Cardigan	465	428	—	—	30	4	3	1·5
Lampeter	318	286	—	—	23	—	9	2·8
Tregaron	300	264	—	—	26	7	3	3·3
CARMARTHEN.								
Carmarthen	1,091	1,000	—	—	70	2	19	1·9
Llanelly	1,636	1,487	—	—	139	—	10	0·6
Llandilo Fawr	575	517	—	—	45	4	9	2·3
Llandovery	445	375	—	—	63	2	5	1·6
Newcastle-in-Emlyn	535	491	—	—	39	2	3	0·9

—	Returns, 1870.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Dead. Unvaccinated.	Vaccination postponed.	Remaining.	Per-centage of Children not finally accounted for, including Cases postponed.
CARNARVON.								
...gor and Beaumaris -	1,161	1,042	3	—	97	2	17	1·6
...rvon - - -	1,483	1,263	—	—	156	9	55	4·3
...ay - - -	550	477	—	—	51	13	9	4·0
...lli - - -	693	595	—	—	54	10	9	2·4
DENBIGH.								
...rwst - - -	439	388	—	—	50	16	5	4·8
...lan - - -	376	342	—	—	28	—	6	1·6
...ham - - -	1,878	1,669	—	—	160	13	31	2·3
FLINT.								
...h St. - - -	856	764	—	—	80	4	8	1·4
...rden - - -	543	496	—	—	43	5	9	2·6
...well - - -	1,443	1,256	1	—	129	12	46	4·0
GLAMORGAN.								
...ond and Cowbridge -	1,342	1,142	—	—	122	14	64	5·8
...l - - -	3,634	3,070	2	1	336	12	243	7·0
...r - - -	354	323	—	—	24	4	3	2·0
...yr Tydfil - -	3,471	3,104	1	—	240	22	54	2·2
...n - - -	1,853	1,664	1	—	146	5	37	2·3
...rdawe - - -	738	634	—	—	82	10	12	3·0
...ypridd - - -	3,594	3,109	—	—	364	14	107	3·4
...sea - - -	3,520	3,160	—	—	275	29	56	2·4
MERIONETH.								
- - - -	184	156	—	—	20	3	5	4·3
...n - - -	497	411	—	—	45	4	27	6·4
...ey - - -	505	446	—	—	49	6	4	2·0
...ros - - -	1,078	932	—	1	107	22	17	3·6
MONTGOMERY.								
...llin - - -	556	488	—	—	53	14	4	3·2
...illeth - -	394	334	—	—	31	13	16	7·4
...n - - -	545	460	—	—	57	12	16	5·1
...wn and Llanidloes -	862	681	—	—	76	7	98	12·2
PEMBROKE.								
...ford west - -	961	856	—	—	92	9	24	3·4
...ftin - - -	632	558	—	—	49	8	22	4·0
...oke - - -	983	860	—	—	78	30	9	4·0
RADNOR.								
...ton - - -	372	316	—	—	37	8	11	5·1
...der - - -	195	169	—	—	21	4	1	2·6

App. A. No. 2.

Inspection of Public Vaccination.

No. 2.

List (alphabetically arranged) of 278 Unions inspected during the Year 1881, with reference to the Proceedings under the Vaccination Acts, 1867 and 1871, and an Account of the Awards made to the respective Public Vaccinators out of Moneys voted by Parliament for that Purpose.

Union.	No. of Vaccination Districts in the Union.	No. of respective Vaccination Contractors recommended for Award.		Range of Awards in each Union.		Total Sum awarded in the Union.	Inspector.
		1st Class Award.	2nd Class Award.	Minimum.	Maximum.		
				£ s. d.	£ s. d.	£ s. d.	
Aberaeron	2	2	—	13 13 0	14 4 0	27 17 0	Mr. Spear.
Aberystwith	4	4	—	10 17 0	17 8 0	59 13 0	Do.
Albans, St.	4	2	—	26 10 0	29 14 0	56 4 0	„ Power.
Alcester	5	2	—	4 15 0	12 16 0	17 11 0	Dr. Parsons.
Alderbury	5	4	—	3 6 0	31 19 0	53 6 0	„ Blaxall.
Altrincham	6	5	—	6 6 0	29 3 0	61 17 0	„ Beard.
Amesbury	2	2	—	6 0 0	11 15 0	17 15 0	„ Blaxall.
Anglesey	3	2	—	8 0 0	13 6 0	21 6 0	„ Parsons.
Asaph, St.	5	1	—	—	—	14 13 0	Do.
Ashford, East	7	6	—	2 1 0	7 13 0	33 11 0	„ Stevens.
Ashford, West	3	2	—	5 2 0	9 19 0	15 1 0	Do.
Ashton-under-Lyne	12	7	—	4 5 0	56 4 0	195 15 0	„ Beard.
Aston	7	6	—	2 11 0	113 7 0	382 17 0	„ Parsons.
Atherstone	2	1	—	—	—	20 17 0	Do.
Auckland	9	8	—	11 9 0	31 12 0	160 12 0	Mr. Spear.
Austell, Saint	7	5	—	4 12 0	21 13 0	61 13 0	Dr. Ballard.
Bala	1	1	—	—	—	13 0 0	„ Parsons.
Banbury	7	3	—	3 18 0	11 3 0	23 8 0	„ Blaxall.
Bangor and Beaumaris.	5	1	—	—	—	26 14 0	„ Parsons.
Barnet	5	2	—	6 19 0	15 11 0	22 10 0	Mr. Power.
Barton-upon-Irwell	6	5	—	3 16 0	55 17 0	124 14 0	Dr. Beard.
Battle	6	3	—	3 1 0	8 16 0	17 4 0	„ Stevens.
Beaminster	5	3	—	1 17 0	7 4 0	12 10 0	„ Blaxall.
Berkhampstead	3	2	—	12 7 0	14 12 0	26 19 0	Mr. Power.
Bethnal Green	2	2	—	76 18 0	194 10 0	271 8 0	Dr. Stevens.
Bicester	7	3	—	2 18 0	12 6 0	22 17 0	„ Blaxall.
Bierley, North	13	9	—	7 1 0	23 13 0	117 17 0	„ Beard.
Billericay	5	3	—	2 8 0	7 8 0	14 12 0	„ Airy.
Birkenhead	2	2	—	36 9 0	109 16 0	146 5 0	„ Beard.
Birmingham	1	1	—	—	—	253 16 0	„ Stevens.
Bishop Stortford	7	3	—	7 5 0	20 2 0	35 10 0	Mr. Power.
Blackburn	10	6	—	14 8 0	41 14 0	167 16 0	Dr. Beard.
Blandford	4	2	—	3 17 0	6 14 0	10 11 0	„ Blaxall.
Blean	4	2	—	4 3 0	12 8 0	16 11 0	„ Stevens.
Bodmin	7	4	—	4 13 0	13 18 0	31 14 0	„ Ballard.
Bolton	8	7	—	3 19 0	131 1 0	318 6 0	„ Beard.
Brackley	5	1	—	—	—	4 9 0	„ Parsons.
Bradford (Wilts)	3	2	—	3 16 0	12 13 0	16 9 0	„ Blaxall.
Bradford (Yorks.)	4	3	—	41 6 0	60 0 0	155 13 0	„ Beard.
Braintree	7	5	—	4 12 0	17 7 0	49 4 0	„ Airy.
Brecknock	3	1	1	2 18 8	26 0 0	28 18 8	Mr. Spear.
Bridge	5	4	—	4 10 0	6 13 0	21 5 0	Dr. Stevens.
Bridgend and Cowbridge.	4	—	—	—	—	—	Mr. Spear.
Bridport	4	3	—	4 16 0	21 11 0	32 1 0	Dr. Blaxall.
Brighton	2	2	—	65 9 0	79 3 0	144 12 0	„ Stevens.
Bristol	1	1	—	—	—	40 5 0	Do.
Bromley	5	5	—	2 15 0	19 7 0	57 19 0	Do.
Builth	1	1	—	—	—	20 14 0	Mr. Spear.
Buntingford	2	2	—	9 2 0	10 8 0	19 10 0	„ Power.
Burnley	7	6	—	1 4 0	44 17 0	89 17 0	Dr. Beard.
Bury	6	3	—	27 18 0	48 9 0	104 6 0	Do.

UNION.	No. of Vaccination Districts in the Union.	No. of respective Vaccination Contractors recommended for Award.		Range of Awards in each Union.		Total Sum awarded in the Union.	Inspector.
		1st Class Award.	2nd Class Award.	Minimum.	Maximum.		
				£ s. d.	£ s. d.	£ s. d.	
[illegible]	1	—	—	—	—	—	Dr. Blaxall.
[illegible]erwell	5	5	—	2 14 0	90 4 0	269 17 0	„ Stevens.
[illegible]rize	1	—	—	—	—	—	„ Airy.
[illegible]ford	2	1	—	—	—	20 4 0	„ Ballard.
[illegible]sbury	1	1	—	—	—	24 18 0	„ Stevens.
[illegible]ff	3	3	—	2 0 0	47 5 0	79 8 0	Mr. Spear.
[illegible]ean	3	3	—	11 3 0	15 16 0	40 12 0	Do.
[illegible]arthen	8	7	—	2 4 0	23 1 0	79 14 0	Do.
[illegible]rvon	5	—	—	—	—	—	Dr. Parsons.
[illegible]nandArrington	3	—	—	7 9 0	9 13 0	25 7 0	„ Airy.
[illegible]	4	1	—	—	—	1 4 0	„ Blaxall.
[illegible]w	4	3	—	0 18 0	8 16 0	16 14 0	„ Stevens.
[illegible]sford	10	8	—	3 3 0	14 2 0	55 3 0	„ Airy.
[illegible]a	2	2	—	31 3 0	89 16 0	120 19 0	„ Stevens.
[illegible]ter	3	1	—	—	—	7 1 0	„ Beard.
[illegible]rle-Street	2	2	—	57 8 0	72 7 0	129 15 0	Mr. Spear.
[illegible]rton	8	5	—	6 1 0	12 8 0	44 10 0	Dr. Airy.
[illegible]ster	1	1	—	—	—	10 2 0	„ Stevens.
[illegible]ham	7	4	—	2 8 0	16 0 0	29 3 0	„ Blaxall.
[illegible]g Norton	4	3	—	5 19 0	14 12 0	29 2 0	Do.
[illegible]n	12	11	—	4 16 0	51 1 0	280 10 0	„ Beard.
[illegible]ster	1	1	—	—	—	45 0 0	„ Airy.
[illegible]St., Major	6	3	—	12 2 0	14 7 0	39 11 0	„ Ballard.
[illegible]on	4	3	—	7 7 0	37 16 0	71 17 0	„ Beard.
[illegible]	2	—	—	—	—	—	„ Parsons.
[illegible]	3	—	—	—	—	—	Do.
[illegible]ck	6	4	—	2 0 0	5 15 0	14 14 0	„ Stevens.
[illegible]well	2	1	—	—	—	12 11 0	Mr. Spear.
[illegible]le and Wootsett.	3	3	—	6 15 0	19 8 0	26 3 0	Dr. Blaxall.
[illegible]d	6	5	—	2 13 0	11 4 0	36 15 0	„ Stevens.
[illegible]rd	5	5	—	13 1 0	20 17 0	107 2 0	Do.
[illegible]	2	1	—	—	—	60 16 0	„ Beard.
[illegible]s	6	3	—	6 3 0	17 6 0	33 7 0	„ Blaxall.
[illegible]ary	11	7	—	10 10 0	39 6 0	135 2 0	„ Beard.
[illegible]y	5	4	—	5 12 0	8 14 0	30 6 0	„ Parsons.
[illegible]ster	6	3	—	4 9 0	6 10 0	16 17 0	„ Blaxall.
[illegible]	4	2	—	2 10 0	5 13 0	8 3 0	„ Stevens.
[illegible]w	6	3	—	6 9 0	8 12 0	22 13 0	„ Airy.
[illegible]	5	2	—	24 18 0	33 7 0	58 5 0	Mr. Spear.
[illegible]n	5	2	—	28 4 0	41 14 0	69 18 0	Do.
[illegible]ge	4	4	—	2 13 0	32 17 0	42 13 0	Dr. Stevens.
[illegible]stead	6	5	—	4 0 0	9 0 0	53 18 0	Do.
[illegible]	7	7	—	3 7 0	12 9 0	55 6 0	Do.
[illegible]ston	3	2	—	11 15 0	15 7 0	27 2 0	Do.
[illegible]	5	4	—	5 10 0	38 14 0	64 15 0	Do.
[illegible]	7	4	—	0 3 0	9 12 0	19 11 0	„ Airy.
[illegible]	10	5	—	4 3 0	9 12 0	29 17 0	Do.
[illegible]	1	1	—	—	—	49 10 0	„ Stevens.
[illegible]h	4	1	—	—	—	5 15 0	„ Ballard.
[illegible]nn	4	4	—	2 14 0	39 0 0	67 19 0	„ Stevens.
[illegible]	4	—	—	—	—	—	„ Parsons.
[illegible]	5	—	—	—	—	—	Do.
[illegible]	4	—	—	—	—	—	Do.
[illegible]he	5	4	—	10 4 0	19 7 0	59 6 0	„ Beard.
[illegible]d	5	2	—	25 2 0	94 18 0	120 0 0	Mr. Spear.
[illegible]St., in the	1	1	—	—	—	98 9 0	Dr. Stevens.
[illegible], St.	6	2	—	6 8 0	13 5 0	19 13 0	„ Ballard.
[illegible]	2	2	—	9 8 0	20 9 0	29 17 0	Mr. Spear.
[illegible]d and Milton	1	1	—	—	—	30 13 0	Dr. Stevens.

App. A. No. 2.

Inspection of Public Vaccination.

UNION.	No. of Vaccination Districts in the Union.	No. of respective Vaccination Contractors recommended for Award.		Range of Awards in each Union.		Total Sum awarded in the Union.	Inspector.
		1st Class Award.	2nd Class Award.	Minimum.	Maximum.		
				£ s. d.	£ s. d.	£ s. d.	
Hackney	4	3	—	30 16 0	66 16 0	145 6 0	Dr. Stevens.
Hailsham	7	4	—	2 3 0	4 9 0	14 4 0	Do.
Halstead	5	3	—	5 16 0	12 18 0	25 8 0	„ Airy.
Hardingstone	3	1	2	2 1 4	6 5 0	12 15 0	„ Parsons.
Hartlepool	3	2	—	2 18 0	20 0 0	31 18 0	Mr. Spear.
Haslingden	6	5	—	13 6 0	39 5 0	135 9 0	Dr. Beard.
Hastings	2	2	—	1 0 0	49 5 0	50 5 0	„ Stevens.
Hatfield	3	—	—	—	—	—	Mr. Power.
Haverfordwest	4	1	—	—	—	13 15 0	„ Spear.
Hawarden	3	2	—	17 4 0	20 13 0	37 17 0	Dr. Parsons.
Hay	3	3	—	6 17 0	9 14 0	24 10 0	Mr. Spear.
Headington	2	2	—	9 19 0	49 0 0	58 19 0	Dr. Blaxall.
Helston	4	3	—	13 2 0	29 1 0	58 13 0	„ Ballard.
Hemel Hempstead	4	—	—	—	—	—	Mr. Power.
Henley	6	3	—	4 8 0	5 3 0	14 2 0	Dr. Blaxall.
Hertford	5	1	—	—	—	18 5 0	Mr. Power.
Highworth and Swindon.	4	—	—	—	—	—	Dr. Blaxall.
Hitchin	5	5	—	14 18 0	30 0 0	97 3 0	Mr. Power.
Hollingbourn	6	5	—	2 13 0	8 0 0	24 13 0	Dr. Stevens.
Holyhead	3	2	—	8 8 0	16 17 0	25 5 0	„ Parsons.
Holywell	5	3	—	22 2 0	37 18 0	92 17 0	Do.
Hoo	1	1	—	—	—	9 1 0	„ Stevens.
Horsham	6	6	—	2 13 0	21 14 0	51 18 0	Do.
Houghton-le-Spring	3	3	—	18 6 0	38 13 0	78 6 0	Mr. Spear.
Hoxne	8	7	—	0 12 0	9 6 0	29 7 0	Dr. Airy.
Huddersfield	16	10	—	2 18 0	32 5 0	155 3 0	„ Beard.
Hunslet	3	2	—	1 15 0	62 16 0	64 11 0	Do.
Huntingdon	5	5	—	5 12 0	15 0 0	44 5 0	„ Airy.
Islington, St. Mary	5	3	—	41 11 0	79 16 0	184 10 0	Dr. Stevens.
Ives, St.	5	5	—	1 8 0	10 1 0	30 4 0	„ Airy.
Knighton	5	3	—	5 5 0	6 8 0	17 7 0	Mr. Spear.
Lambeth	5	4	—	16 18 0	89 11 0	209 8 0	Dr. Stevens.
Lampeter	2	—	—	—	—	—	Mr. Spear.
Lanchester	4	3	—	7 1 0	58 10 0	89 7 0	Do.
Launceston	8	—	—	—	—	—	Dr. Ballard.
Leeds	7	7	—	2 4 0	53 13 0	169 2 0	„ Stevens.
Lewes	1	1	—	—	—	13 3 0	Do.
Lewisham	5	5	—	7 2 0	24 17 0	87 13 0	Do.
Lexden and Winstree	10	9	—	1 2 0	10 17 0	47 19 0	„ Airy.
Linton	3	1	—	—	—	8 16 0	Do.
Liskeard	6	3	—	5 10 0	17 15 0	30 17 0	„ Ballard.
Liverpool	3	3	—	49 10 0	98 14 0	224 3 0	„ Stevens.
Llandilo Fawr	4	3	—	5 13 0	20 15 0	41 0 0	Mr. Spear.
Llandovery	2	—	—	—	—	—	Do.
Llanelly	3	1	—	—	—	76 5 0	Do.
Llanfyllin	5	—	—	—	—	—	Dr. Parsons.
Llanrwst	2	1	—	—	—	15 15 0	Do.
London, City of	2	2	—	21 8 0	22 11 0	43 19 0	„ Stevens.
Macclesfield	6	6	—	1 16 0	55 13 0	100 12 0	„ Beard.
Machynlleth	5	—	—	—	—	—	„ Parsons.
Maidstone	5	5	—	3 10 0	62 4 0	91 8 0	„ Stevens.
Maldon	8	4	—	6 2 0	10 10 0	34 18 0	„ Airy.
Malling	4	3	—	12 3 0	17 10 0	44 12 0	„ Stevens.
Malmesbury	4	3	—	7 3 0	9 11 0	24 7 0	„ Blaxall.
Manchester	3	2	—	41 1 0	57 4 0	98 5 0	„ Stevens.
Marlborough	2	2	—	3 19 0	12 9 0	16 8 0	„ Blaxall.
Marylebone, Saint	1	1	—	—	—	134 15 0	„ Stevens.
Medway	3	3	—	32 2 0	51 16 0	127 3 0	Do.
Melksham	2	1	—	—	—	22 16 0	„ Blaxall.
Mere	2	2	—	3 19 0	9 6 0	13 5 0	Do.
Meriden	3	2	—	2 2 0	7 16 0	9 18 0	„ Parsons.
Merthyr Tydfil	9	6	—	10 12 0	61 9 0	203 18 0	Mr. Spear.
Midhurst	4	3	—	5 4 0	13 16 0	24 18 0	Dr. Stevens.
Mile End Old Town	2	2	—	63 8 0	103 19 0	167 7 0	Do.
Milton	2	2	—	20 0 0	34 10 0	54 10 0	Do.

App. A. No. 2.

Inspection of Public Vaccination.

UNION.	No. of Vaccination Districts in the Union.	No. of respective Vaccination Contractors recommended for Award.		Range of Awards in each Union.		Total Sum awarded in the Union.	Inspector.
		1st Class Award.	2nd Class Award.	Minimum.	Maximum.		
				£ s. d.	£ s. d.	£ s. d.	
Nantwich - - -	8	4	—	5 7 0	43 15 0	71 9 0	Dr. Beard.
Narberth - - -	4	1	—	—	—	12 11 0	Mr. Spear.
Neath - - -	7	3	—	5 16 0	30 11 0	57 6 0	Do.
Nett's, St. - -	6	4	—	2 9 0	13 2 0	29 9 0	Dr. Airy.
Newcastle-in-Emlyn	3	—	—	—	—	—	Mr. Spear.
Newcastle-on-Tyne -	2	4	—	27 14 0	51 11 0	144 4 0	Dr. Stevens.
Newhaven - - -	5	5	—	0 18 0	11 5 0	20 7 0	Do.
Newmarket - -	8	6	—	5 15 0	13 11 0	54 16 0	„ Airy.
Newtown and Llanidloes.	4	2	—	2 8 0	19 4 0	21 12 0	„ Parsons.
North Aylesford -	2	2	—	25 7 0	32 11 0	57 18 0	„ Stevens.
North Witchford -	4	3	—	6 10 0	16 12 0	31 2 0	„ Airy.
Nuneaton - - -	2	—	—	—	—	—	„ Parsons.
Oldham - - -	6	3	—	12 11 0	35 14 0	65 3 0	„ Beard.
Ongar - - -	6	—	—	—	—	—	„ Airy.
Ormskirk - - -	7	3	—	7 11 0	47 18 0	63 15 0	„ Beard.
Orsett - - -	6	5	—	3 5 0	11 18 0	36 9 0	„ Airy.
Oxford - - -	1	1	—	—	—	42 15 0	„ Blaxall.
Paddington - -	2	2	—	42 17 0	50 16 0	93 13 0	„ Stevens.
Pancras, St. - -	1	1	—	—	—	306 13 0	Do.
Pembroke - - -	6	2	—	23 13 0	39 8 0	62 1 0	Mr. Spear.
Penzance - - -	5	3	—	10 16 0	34 7 0	70 4 0	Dr. Ballard.
Petworth - - -	4	4	—	3 3 0	7 2 0	20 9 0	„ Stevens.
Pewsey - - -	5	2	—	2 12 0	10 4 0	12 16 0	„ Blaxall.
Pontardawe - -	2	2	—	29 1 0	31 3 0	60 4 0	Mr. Spear.
Pontypridd - -	8	2	—	10 1 0	13 5 0	23 6 0	Do.
Poole - - - -	4	3	—	5 4 0	12 0 0	23 8 0	Dr. Blaxall.
Potterspury - -	4	1	—	—	—	18 17 0	„ Parsons.
Prescot - - -	8	4	—	9 15 0	68 2 0	176 9 0	„ Beard.
Prestwich - - -	6	4	—	5 6 0	86 14 0	180 11 0	Do.
Pwllheli - - -	5	3	—	7 11 0	9 16 0	25 3 0	„ Parsons.
Truth - - -	6	4	—	18 3 0	29 16 0	91 6 0	„ Ballard.
Ryander - - -	2	1	—	—	—	5 7 0	Mr. Spear.
Ryebridge - - -	5	3	—	5 5 0	8 2 0	18 18 0	Dr. Airy.
Rydale - - -	6	5	—	3 5 0	80 15 0	120 17 0	„ Beard.
Rykford - - -	5	4	—	2 7 0	17 11 0	37 0 0	„ Airy.
Rysford - - -	7	3	—	3 3 0	26 12 0	52 15 0	Do.
Rye and Romney Marsh	3	2	—	1 14 0	5 12 0	7 6 0	„ Stevens.
Ryston - - -	6	2	—	19 6 0	28 17 0	48 3 0	„ Thorne.
Ryby - - -	8	—	—	—	—	—	„ Parsons.
Sacorn - - -	4	3	—	7 12 0	17 7 0	28 3 0	„ Beard.
Saltash - - -	3	—	—	—	—	—	„ Parsons.
Sandbach - - -	3	2	—	6 2 0	15 13 0	21 15 0	„ Stevens.
Saron Walden -	7	4	—	1 15 0	18 17 0	34 4 0	„ Airy.
Scarborough - -	3	3	—	63 10 0	144 1 0	331 11 0	„ Stevens.
Scilford - - -	5	3	—	2 18 0	11 13 0	22 7 0	„ Airy.
Scilly, St. - -	5	5	—	43 12 0	69 18 0	284 2 0	„ Stevens.
Scofield - - -	4	1	—	—	—	10 9 0	Mr. Spear.
Scoaks - - -	6	5	—	3 7 0	10 6 0	38 17 0	Dr. Stevens.
Scresbury - -	3	1	—	—	—	12 3 0	„ Blaxall.
Sedgefield - -	6	6	—	12 10 0	58 1 0	202 7 0	„ Stevens.
Selsey - - -	2	2	—	6 11 0	28 17 0	35 8 0	Do.
Shaborne - - -	3	2	—	3 1 0	6 2 0	9 3 0	„ Blaxall.
Shardull - - -	4	2	—	6 6 0	12 13 0	18 19 0	„ Parsons.
Sheppam - - -	4	2	—	1 0 0	8 3 0	9 3 0	Do.
Shipming - - -	5	5	—	6 5 0	36 14 0	80 9 0	„ Stevens.
Shipston - - -	3	2	—	6 4 0	50 13 0	56 17 0	Mr. Spear.
Shipton-on-Avon	7	4	—	1 13 0	15 1 0	29 13 0	Dr. Parsons.
Shorton - - -	2	1	—	—	—	14 15 0	„ Ballard.
Skipminster - -	4	3	—	4 0 0	8 7 0	17 4 0	„ Blaxall.
Skirland - - -	5	3	—	8 2 0	42 18 0	80 6 0	Mr. Spear.
Skirsea - - -	3	3	—	31 14 0	120 9 0	259 10 0	Do.

App. A. No. 2.

Inspection of Public Vaccination.

UNION.	No. of Vaccination Districts in the Union.	No. of respective Vaccination Contractors recommended for Award.		Range of Awards in each Union.		Total Sum awarded in the Union.	Inspector.
		1st Class Award.	2nd Class Award.	Minimum.	Maximum.		
				£ s. d.	£ s. d.	£ s. d.	
Tarvin	2	1	—	—	—	9 18 0	Dr. Beard.
Tendring	11	7	—	4 11 0	15 13 0	58 12 0	„ Airy.
Tenterden	6	3	—	3 12 0	7 18 0	16 8 0	„ Stevens.
Thakeham	2	2	—	9 8 0	12 11 0	21 19 0	Do.
Thame	6	3	—	0 9 0	10 10 0	18 7 0	„ Blaxall.
Thanet, Isle of	4	4	—	10 5 0	39 10 0	83 1 0	„ Stevens.
Ticehurst	8	4	—	0 17 0	8 13 0	21 0 0	Do.
Tisbury	3	1	—	—	—	6 11 0	„ Blaxall.
Tonbridge	6	4	—	6 18 0	23 5 0	49 10 0	„ Stevens.
Towcester	4	1	—	—	—	10 9 0	„ Parsons.
Toxteth Park	2	2	—	45 18 0	142 15 0	188 13 0	„ Stevens.
Tregaron	2	—	—	—	—	—	Mr. Spear.
Truro	7	2	—	4 16 0	7 0 0	11 16 0	Dr. Ballard.
Uckfield	6	6	—	1 13 0	12 2 0	55 1 0	„ Stevens.
Wakefield	6	5	—	8 12 0	53 14 0	151 11 0	„ Beard.
Wandsworth and Clapham.	7	6	—	12 4 0	125 14 0	302 0 0	„ Stevens.
Ware	8	4	—	3 8 0	18 6 0	40 10 0	Mr. Power.
Wareham and Purbeck.	7	3	—	5 13 0	6 13 0	18 4 0	Dr. Blaxall.
Warminster	5	5	—	2 15 0	13 1 0	30 10 0	Do.
Warrington	4	3	—	8 8 0	89 8 0	134 5 0	„ Beard.
Warwick	3	1	—	—	—	16 15 0	„ Parsons.
Watford	5	2	—	12 8 0	15 12 0	28 0 0	Mr. Power.
Weardale	5	4	—	2 5 0	17 5 0	35 13 0	„ Spear.
Welwyn	1	1	—	—	—	6 18 0	„ Power.
Westbourne	3	3	—	1 17 9	7 18 0	14 19 0	Dr. Stevens.
Westbury and Whorwelsdown.	4	4	—	2 15 0	15 14 0	25 3 0	„ Blaxall.
West Derby	6	4	—	13 12 0	182 15 0	387 14 0	„ Stevens.
West Firle	3	3	—	1 7 0	2 6 0	5 12 0	Do.
West Ham	9	7	—	6 19 0	98 15 0	305 10 0	„ Airy.
West Hampnett	5	3	—	4 14 0	14 7 0	25 1 0	„ Stevens.
Weymouth	6	3	—	1 5 0	23 9 0	37 8 0	„ Blaxall.
Whittlesey	2	2	—	7 0 0	7 10 0	14 10 0	„ Airy.
Wigan	8	6	—	27 18 0	107 14 0	318 5 0	„ Beard.
Wilton	4	2	—	5 6 0	9 16 0	15 2 0	„ Blaxall.
Wimborne and Cranborne.	4	1	—	—	—	16 3 0	Do.
Wirrall	4	2	—	13 7 0	17 10 0	30 17 0	„ Beard.
Wisbech	14	8	—	2 6 0	16 10 0	54 9 0	„ Airy.
Witney	4	1	—	—	—	13 9 0	„ Blaxall.
Woodbridge	4	3	—	8 5 0	14 5 0	34 7 0	„ Airy.
Woodstock	5	2	—	6 4 0	6 7 0	12 11 0	„ Blaxall.
Woolwich	3	4	—	2 5 0	45 14 0	101 13 0	„ Stevens.
Wrexham	5	3	—	8 1 0	83 6 0	100 11 0	„ Parsons.
Total	1,289	808	3	—	—	16,836 19 8	

Supplementary List of Awards made in 1881 to Public Vaccinators in a Union which was inspected in 1880.

Northwich	7	4	—	2 3 0	34 5 0	66 5 0	Dr. Beard.

No. 3.

Statistics of the National Vaccine Establishment and Educational Vaccination Stations.

Ia.—Staff at end of 1881.

N.B.—**The stations named in *italics* are Educational Vaccination Stations authorised by the Local Government Board.**

—	Name.	Vaccination Stations.	Days and Hours of Attendance.
accinators supplying ymph for the public ervice, & salaried rom the Parliamentary rant.	1. Dr. R. Cory	*Victoria Hall*	Tues., Thurs.; 1.
	2. Mr. W. E. G. Pearse	*Tottenham Court Chapel.*	Mon., Wednes.; 1.
rochial nd other accinators not alaried rom the arliamentary rant, ut contributing ymph at fixed ate of ayment.	1. Mr. Ellis S. Guest	*Manchester*	Monday; 2.
	2–6. Dr. Edmund Robinson.	*Birmingham*	Monday; Tuesday; Wednesday; 11. Wednesday; 2. Thursday; 11.
	7. Mr. Roger Parker	*Liverpool*	Thursday; 2.30.
	8. Mr. E. L. Webb	*Pimlico*	Thursday; 10.
	9. Mr. J. Hawthorn	*Newcastle-on-Tyne.*	Wednesday; 3.
	10. Mr. W. E. G. Pearse	*Westminster*	Tuesday; 2.
	11–12. Mr. W. A. Sumner	*Marylebone*	Tuesday; 2. Wednesday; 10.
	13. Mr. C. T. Blackman	*Whitechapel*	Wednesday; 11.
	14. Mr. Frederick Holmes	*Leeds*	Tuesday; 2.30.
	15. Dr. Edward Lynes	Coventry	Tuesday; 12.
	16. Dr. Hugh Thomson	*Glasgow*	Monday; 12.
	17. Vacant*	*Exeter*	—
	18. Mr. Robert W. Dunn	*Strand*	Thursday; 11.
	19. Mr. Matthew Brownfield	Bromley, Middlesex.	Tuesday; 3.
	20. Mr. W. Skinner	*Sheffield*	Tuesday; 3.
	21. Dr. A. C. Clarke	Salford	Thursday; 2.
	22. Mr. N. Miskin	Waterloo	Tuesday; 2.
	23. Mr. T. F. Morrish	Toxteth Park	Tuesday; 11.
	24. Dr. J. O. Affleck	*Edinburgh*	Wednes., Sat.; 1.
	25. Dr. R. Cory	*St. Thomas's Hosp.*	Wednesday; 11.30.
	26. Dr. D. C. McVail	*Glasgow West*	Monday; 1.
hers of accinators not pplying mph	Dr. W. Husband	*Edinburgh*	Wednes., Sat.; 12.
	Dr. R. D. Tannahill	*Glasgow*	Mond., Thurs.; 12.
	Mr. H. Lawrence	*Bristol*	Wednesday; 10.
	Mr. J. Gittins	*Horsleydown*	Monday; 2.

Since the close of 1881 Mr. William A. Budd has been appointed Educational inator at Exeter. His attendances at the Station are given on Thursdays at n.

I*b*.—Animal Vaccination.

The Animal Vaccine Station is at 95, Lamb's Conduit Street, where Dr. R. Cory and Mr. S. F. Murphy attend for the Vaccination of Children on Tuesdays and Thursdays, from 10.30 a.m. to 12 noon.

II.—Sources and Amount of Lymph Supply in 1881.

N.B.—The Stations named in *italics* are Educational Vaccination Stations authorised by the Local Government Board.

—	Vaccination Stations.	Number of Vaccinations performed at the Stations respectively.		Number of Charges of Lymph supplied from the Stations respectively.	
		Primary.	Re-vaccinations.	Charged ivory Points.	Charged Tubes each estimated as equal to 10 ivory Points.
Vaccinators salaried from the Parliamentary grant.	1. *Victoria Hall* -	377	471	4,983	—
	2. *Tottenham Court Chapel.*	891	371	160*	577
	Total -	1,268	842	5,143	577
Parochial and other Vaccinators not salaried from the Parliamentary grant, but contributing lymph at a fixed rate of payment.	1. *Manchester*† -				
	2–6. *Birmingham* -	6,218	459	—	4,406
	7. *Liverpool* -	1,567	187	—	999
	8. *Pimlico* - -	653	622	—	751
	9. *Newcastle-on-Tyne.*	649	23	—	981
	10. *Westminster* -	918	524	—	534
	11–12. *Marylebone* -	1,601	975	—	434
	13. *Whitechapel* -	1,844	396	—	329
	14. *Leeds* - -	1,068	—	—	435
	15. Coventry -	997	5	—	1,249
	16. *Glasgow* - -	950	3	—	478
	17. *Exeter*‡ - -	199	7	—	—
	18. *Strand* - -	434	441	—	—
	19. Bromley - -	1,583	269	—	126
	20. *Sheffield* - -	1,240	—	—	149
	21. Salford - -	802	—	—	1,307
	22. Waterloo -	704	159	—	1,541
	23. Toxteth Park -	1,788	80	—	2,099
	24. *Edinburgh* -	1,101	13	—	93
	25. *St. Thomas's Hospital.*	635	196	—	537
	26. *Glasgow West*	629	—	—	494
	Total -	25,575	4,359	—	16,942
	Grand Total -	26,843	5,201	5,143	17,519

* This number includes 40 charged glasses, each estimated as equal to four charged ivory points.

† No information received from this station.

‡ For four months only.

II.—Sources and Amount of Lymph, &c.—*continued.* App. A. No. 3.

National Vaccine Establishment.

During the year additional supplies (to the extent of 9,038 charged tubes) were obtained from the following gentlemen —

Mr. C. C. Claremont, Hampstead Road.
Mr. W. Kempster, Battersea East.
Mr. G. A. H. Hepworth, Gloucester.
Mr. J. H. Webster, Nottingham.
Dr. H. Cuolahan, St. Olave's.
Mr. J. Oakman, Battersea West.
Mr. W. Arthur, Kennington.
Dr. M. A. Macdonnell, Toxteth Park.
Mr. H. May, Aston.
Mr. T. Harper, Plymouth.
Dr. J. F. Porter, Bow.
Mr. W. F. Carter, Bedminster.
Mr. H. W. Newton, Newcastle-on-Tyne.
Mr. W. H. W. Wilkinson, Liverpool Road.
Mr. J. P. Purvis, Greenwich.
Mr. J. W. Kay, St. George's-in-the-East.
Dr. N. E. Roberts, Toxteth Park.
Dr. T. N. Orchard, Pendleton.
Mr. T. M. Johnson, Salford.

III.—Distribution of Human Lymph, 1881.

Number of applications:	
From Medical Practitioners in England and Wales	11,435
„ „ „ Scotland	209
„ the Army	504
„ the Navy and from the Emigration Department	73
„ India and the Colonies	160
„ Diplomatic and other Foreign Services	87
Total	12,468
upplies sent out :—	
Charged ivory points	8,195
„ squares of glass	40
„ capillary tubes	24,572

IV. Calf-Lymph, 1881.

umber of applications	96
mount received :—	
Charged points	935
„ tubes	39
„ glasses	1
pplies sent out:—	
Charged ivory points	470
„ capillary tubes	30

No. 4.

Abstract of Medical Inspections made in 1881 with regard, generally, to the incidence of Disease on particular places, and to consequent Questions concerning the Local Sanitary Administration.

Area of Inquiry and Name of Inspector.	Ground of Inquiry.	Jurisdiction concerned.	Chief Facts reported by Inspector.
1. Abergele and Pensarn.* (Denbighshire.) Population, 1,916. *Dr. Parsons.*	As to Medical Officer of Health arrangements.	Abergele and Pensarn local board.	*Abergele* is an old market town, *Pensarn* a small watering place of recent origin. Abergele had been sewered by the St. Asaph rural sanitary authority, and Pensarn by the Pensarn local board before the formation of the district as at present constituted. Sewers stated to be of good construction; provided with means of flushing and ventilation; outfall in the sea. Water supply furnished by Rhyl and District Water Company. At Pensarn, in addition, water from a spring is brought by pipes into underground cisterns where it is pumped by hand; this latter supply is liable to be fouled both at its source and in the cisterns. Some houses have indoor waterclosets, others have privies with open middensteads. Soil-pipes not ventilated. Back yards of houses unpaved, with uneven surface and in foul condition. No public scavenging; consequent accumulations of refuse. New houses without sufficient air-space, in disregard of byelaws. Medical Officer of Health's duties efficiently discharged, except as to transmission of annual reports to the Local Government Board.
2. Arlford, near Chester. (Cheshire.) *Dr. Ballard.*	A communication from the Medical Officer of Health. Case of "sausage-poisoning."	- - - -	A man having eaten some tinned (American) sausage was speedily attacked with violent abdominal pain, vomiting, purging, and prostration. In the course of a few days, when these symptoms had abated, symptoms of pneumonia appeared, and the man died on the ninth day after eating the sausage. A post-mortem examination of the body was not made, the coroner having refused to hold an inquest. Some sausages of the same consignment were sent to Dr. Klein, together with a portion of the sausage partaken of. On feeding animals with them, some of the sausages were found innocuous, while others were very poisonous, the symptoms of poisoning not being long delayed. After death the appearances found were hæmorrhage in the stomach, congestion of the lungs, and disease of the kidneys. There was no mineral poison present in the sausage, and an alkaloidal substance extracted by Dr. Dupré was not found to be poisonous. (*See* page 57.)
3. Blackburn - - (Lancashire.) *Dr. Airy.*	Report of Health Officer. Outbreak of enteric fever.	Blackburn town council.	*Blackburn Urban Sanitary District.*—(Pop. 104,012.)—Some enteric fever habitually present. Great increase in March 1881, possibly due to contamination of water-supply by sewage from drain conveying discharges of a fever patient at Guide on line of conduit. General sanitary administration active and efficient. (As) midden privies being replaced by water privies and waterclosets. Excreta taken by canal to manure works. Sewage utilized for farm-irrigation, other refuse destroyed in furnaces. Great works in active progress for new water supply. Small isolation-hospital erected in presence of small-pox. Compulsory notification of infectious disease working well. Health Officer in private practice, with small salary.
		Blackburn rural sanitary authority.	*Blackburn Rural Sanitary District (part of).*—Prevalence of enteric fever at Belthorn in January—May 1881, amongst persons driuking from a well in sandstone rock in dangerous relation to privies on higher ground. Need of more efficient nuisance inspection. (*See* page 74.)

* This district was visited in connexion with a general inquiry as to the "sanitary condition of certain districts "wholly or partly in Denbighshire, with reference to the arrangements for the performance of the duties of Medical "Officer of Health." The other districts included in the inquiry were, the Corwen, Holywell, Ruthin, and St. Asaph rural, and the Denbigh, Llangollen, and Ruthin urban sanitary districts.

Area of Inquiry and Name of Inspector.	Ground of Inquiry.	Jurisdiction concerned.	Chief Facts reported by Inspector.
Bodmin Registration District. (Cornwall.) Population, 19,199. *Dr. Parsons.*	Regis.-General's Returns, and Reports of Medical Officer of Health. Outbreaks of enteric fever.	Bodmin rural sanitary authority.	*Bodmin Rural Sanitary District.*—(Pop. 14,138.)—Scattered outbreaks of fever in various parts of the district, mostly confined to single households, in some cases introduced from other districts, in some others associated with polluted water and privy nuisances. Defective drainage, polluted water supplies, foul cesspit-privies, lack of privy accommodation, and pig-keeping nuisances were met with. Fatal prevalence of scarlet fever at Port Isaac in 1880, associated with ill-ventilated, damp, and overcrowded dwellings.
		Bodmin town council.	*Bodmin Urban Sanitary District.*—(Pop. 5,091.)—Severe epidemic of enteric fever in summer and autumn of 1881. Original source not traced. Sewers and drains badly constructed, leaky, and unventilated. Nuisance at outfall of sewer. Water supply partly from springs and wells exposed to sewage pollution. Possibility of reflux of foul matters into public water supply from closets flushed direct from an intermittent service. Houses without air-space or through ventilation. Nuisances from surface filth, and from keeping of pigs. No byelaws. No supervision over erection of new houses nor over condition of sewers, &c. No hospital accommodation nor disinfecting apparatus.
[illegible] Bridge, [illegible]ford Abbots. (Essex.) *Dr. Airy.*	Local information as to cases of small-pox.	Ongar rural sanitary authority.	Eight cases of small-pox (two fatal) in one cottage, and subsequently one case in another cottage 200 yards to leeward of the first. Origin of outbreak untraceable. No proper hospital in district for isolation purposes. (*See* page 100.)
[illegible]ington - - Yorkshire, East Riding.) [illegible]ation, 8,363. *Dr. Parsons.*	Enteric fever. Information received from General Inspector of the district and Registrar-General's Returns.	Bridlington local board.	Sudden and extensive outbreak of enteric fever in September and October 1880, especially incident upon households obtaining milk from a particular dairy. Well water used for dairy purposes polluted, and possibly specifically infected. Enteric fever also persisting in certain ill-drained localities. Want of sewers, especially in the middle portion of the district. Nuisances from cesspools, defective house drains, and foul open water courses. Liability to floods. No hospital accommodation for cases of infectious disease.
[illegible]ey - - [illegible]shire.) [illegible]ation, 19,472. *Dr. Parsons.*	Fever prevalence. Registrar-General's Returns.	Chorley improvement commissioners.	Recent epidemic of scarlet fever. Enteric fever somewhat prevalent of late, due probably to local causes. Much of the "fever" not of a specific nature. Hospital accommodation for infectious cases provided at the workhouse only, and but little used. General sanitary condition satisfactory.
[illegible]wall" school [illegible]p. *Dr. Power.*	Information from School Ship Society as to enteric fever.	- - - -	Outbreak of enteric fever on board the vessel. Inquiry, undertaken two months after outbreak, failed to indicate any useful clue to the source of the disease.
[illegible]l Rural Sanitary District.* [illegible]lshire and [illegible]ethshire.) [illegible]on, 13,706. *Parsons.*	As to Medical Officer of Health arrangements.	Corwen rural sanitary authority.	Sewers have been provided in Gwyddelwern and part of Corwen. Other places in district unsewered or with old faulty drains; a source of nuisance. Pollution by sewage, privies, and flannel mills, of streams used for drinking. Water supply in some places scanty and difficult of access; in others, liable to contamination. Privies, even new ones, of faulty construction: in Corwen partly replaced by waterclosets. Houses partly underground, damp, dilapidated, ill-ventilated, and over-crowded. Three Medical Officers of Health, two of whom (one recently deceased) Poor Law Medical Officers. Judging from the character of their reports, and the condition of the district, their duties appear to have been unequally, but on the whole inefficiently, performed.

* See footnote on page 26.

Area of Inquiry and Name of Inspector.	Ground of Inquiry.	Jurisdiction concerned.	Chief Facts reported by Inspector.
10. Denbigh* - - (Denbighshire.) Population, 6,491. *Dr. Parsons.*	As to Medical Officer of Health arrangements and action taken since previous inspection.	Denbigh town council	Water supply increased and service extended. Certain polluted sources still accessible. Sewerage system completed. House drains with inlets of defective construction: some in untrapped communication with interior of houses. The use of water-closets considerably extended, but many midden privies of a very objectionable kind remain, even in close proximity to dwelling-houses. No public arrangements for removal of privy contents, hence large accumulations of excrement and refuse. Pig-keeping nuisances persist. Large deposits of manure close to houses. These conditions prevail to a especial extent in the outlying village of Henllan, which is unsewered, and of which the water supply is scanty, difficult of access, and exposed to contamination. No hospital accommodation for infectious diseases. Duties of Medical Officer of Health inefficiently performed.
11. Durham Registration District. (Durham.) Population, 63,586. *Mr. Spear.*	Continued excessive prevalence of scarlatina shown by the Registrar - General's returns.	Durham urban sanitary authority.	*City of Durham.*—(Pop. 17,161.)—Almost entire abrogation by the Sanitary Authority of its functions. Services of Medical Officer of Health for the last two years not available. practically no sanitary inspection. Many dwellings unfit for habitation. prevalence of sewage and privy nuisances. No effort made to check the spread of infectious disease.
		Durham rural sanitary authority.	*Durham Rural Sanitary District*—(Pop. 36,000.)—No public sewerage, and the drainage of many of the populous colliery villages such as to give rise to serious nuisance. In many of the villages gross nuisances from long storage of refuse; and in some, water supplies derived from sources exposed to pollution. The dwellings in certain of the older villages unfit for habitation, and several of recent date erected without due regard to stability or to sanitary requirements. No provision made for dealing with the spread of infectious disease.
		Brandon and Byshottles urban sanitary authority.	*Brandon and Byshottles Urban Sanitary District.*—(Pop. 10,550.—A district presenting all the defects referred to above as belonging to the rural district, of which, until lately, it was a part, except that since the formation of the present urban district considerable improvement has been made in the sewerage of certain localities. No provision for dealing with the spread of infectious disease. Unrestrained intercourse between infected and non-infected households. (*See* page 70.)
12. Great Grimsby - (Lincolnshire.) Population, 29,663. *Dr. Parsons.*	Insufficient information from reports of Medical Officer of Health as to sanitary state of borough.	Great Grimsby town council.	Considerable improvement since Dr. Home's inspection in 1871. New sewer outfalls. Loan applied for for new sewers to prevent pollution of open watercourses. Box closets in general use, and regularly emptied. Use of company's water extended. Pig-keeping and other nuisances abated. Some defects in house drainage. Offensive trades. No hospital accommodation for infectious diseases other than small pox.
13. Gunnislake - (Cornwall.) *Dr. Blaxall.*	Local information as to scarlatina and diphtheria prevalence.	Tavistock rural sanitary authority.	Concurrence of scarlatina and diphtheria. Epidemic of diphtheria due to personal intercommunication between infected and healthy at the schools. No efficient measures taken to prevent the spread of the disease which is endemic in the district. Several privies in a filthy condition. General sanitary condition of the village eminently unsatisfactory.

* See footnote on page 26.

...n of Inquiry and ...ns of Inspector.	Ground of Inquiry.	Jurisdiction concerned.	Chief Facts reported by Inspector.
...lifax - (Yorkshire.) ...ulation, 78,621. *Dr. Ballard.*	Request of inhabitants on epidemic of scarlatina.	Halifax town council.	Scarlatina habitually present in and about borough. Special rapid extension in the first weeks of 1881, chiefly incidence on two wards (south and west wards). A particular milk supply (the milk being delivered by a man who at the time had scarlatina in his family) was concerned in the spread of the disease. Very insufficient action taken by the sanitary authority to check the outbreak. (See page 46.)
...nkley - ...ester and Warwick.) ...ulation, 1,672. *Dr. Airy.*	Enteric fever. Local complaint.	Hinckley local board.	Severe outbreak of enteric fever in July-August 1881, in an elevated part of the town. Water from wells in danger of pollution and liable to drought. (New scheme of water supply on foot.) Nuisances from foul drainage, privies, middens, pigstyes, and lost-houses. Necessary inspection and abatement inefficient. No public means of isolation of infectious disease, nor of disinfection, except by chemicals.
...ywell Rural ...itary District.* ...lire and Denbighshire.) ...ulation, 87,976. *Parsons.*	As to Medical Officer of Health arrangements and action taken since former inspection.	Holywell rural sanitary authority.	A densely populated mining and manufacturing district; many parts urban in character, but no urban powers possessed by sanitary authority. Sanitary works confined to sewerage of one village, and erection of one or two pumps. Drainage very defective; grave consequent nuisances, especially in the low-lying places near the Dee estuary. Water supply in many places scanty, laborious of access, and inferior in quality. Offensive midden privies. Houses unfit for habitation. No supervision over erection of new buildings. No hospital accommodation nor disinfecting apparatus. Two Medical Officers of Health whose duties have been properly discharged and who have reported jointly on matters affecting the district as a whole.
...ell Urban ...itary District, ...tshire.) ...ation, 3,091. *Parsons.*	As to action taken by sanitary authority since former inspection.	Holywell local board.	No proper sewerage. Defective house drains. Privy nuisances. Surface filth. Water supply insufficient. Wells of doubtful purity resorted to. No proper arrangements for removal of night-soil and refuse. Little improvement effected since Dr. Buzzall's inspection in 1875.
...ural Sanitary ...rict. ...ation, 3,397. *...Airy.*	Enteric fever. Report of Medical Officer of Health.	Hoo rural sanitary authority.	Enteric fever at Lower Stoke in August-November 1881, among persons drinking spring water contaminated with surface drainage. Want of water at High Halstow. Privy and slop nuisances frequent. Discord between sanitary officers. Sanitary administration tardy and imperfect.
...Rural Sanitary ...District. ...shire.) ...on, 13,287. *...Spear.*	Enteric fever. Registrar-General's Returns, and absence of any satisfactory information from local sources.	Howden rural sanitary authority.	Localised outbreaks of enteric fever in different villages. Water supplies from shallow wells much exposed to excremental pollution. In two villages, where schools had been closed in consequence of prevalence of fever amongst the school children, outbreaks found to follow opportunities of specific pollution of the school wells. Administration of the district unsatisfactory, and duties of Medical Officers of Health perfunctorily performed.

* See footnote on page 28.

Area of Inquiry and Name of Inspector.	Ground of Inquiry.	Jurisdiction concerned.	Chief Facts reported by Inspector.
20. Ilkeston - - (Derbyshire.) Population, 14,119. *Dr. Blaxall.*	Regis.-General's Returns showing epidemic of enteric fever.	Ilkeston local board -	Extensive epidemic of enteric fever due mainly to infected sewerage escaping within and about dwellings. Certain groups of cases referable to infected privies and polluted water. Frequent recurrence of epidemics of scarlatina, &c. General and zymotic death rate high and increasing. General prevalence of excremental nuisance consequent on the storage of excrement in large unwholesome privy pits. Removal of privy contents effected by authority at a cost prohibitory to frequent removal. Town water supply of good quality but distributed to little more than half the town—the remaining portion procuring water from wells and rain-water tanks, which are greatly exposed to contamination from being sunk in a filth-sodden soil, and the tanks moreover in direct communication with the sewers by means of overflow-pipes. Sewage discharged into the Newark canal and river. Scheme adopted to dispose of the sewage on land. No provision for the flushing or ventilation of the sewers. Heads of sewers closed, outlets open and exposed to the wind. Drains unventilated, inlets untrapped, sink-pipes from within dwellings in direct communication with sewers. No means of isolation for the reception of infectious cases and no disinfecting apparatus provided. Water supply improved since Dr. Buchanan inspected the district in 1870, otherwise little or nothing done to improve the sanitary condition.
21. Llangollen*- - (Denbighshire.) Population, 3,124. *Dr. Parsons.*	As to Medical Officer of Health arrangements.	Llangollen local board	Pollution of river Dee by sewers and privies. Waterclosets mostly in use, but some objectionable privies. Water supply good. Old houses ill ventilated: newly-built houses without the amount of air-space prescribed by the byelaws. Duties of Medical Officer of Health fairly well performed.
22. Llanfyllin Rural Sanitary District. (Montgomeryshire and Denbighshire.) Population, 18,879. *Dr. Parsons.*	Reports of Medical Officers of Health.	Llanfyllin rural sanitary authority.	Many old cottages ill-constructed, damp, badly ventilated, and out of repair. Parts of the district affected injuriously by floods. In most parts of the district no sewers. Pollution of streams by house drainage and contents of privies. Privy accommodation insufficient. Offensive cesspit privies. Scavenging defective. Water supply in some places insufficient and in danger of pollution. Outbreak of diphtheria at Llanwddyn in 1880, origin not ascertained, apparently propagated by infection.
23. Melton Mowbray Rural Sanitary District. (Leicestershire.) Population, 14,843. *Dr. Blaxall.*	Insufficiency of reports of Medical Officers of Health.	Melton Mowbray rural sanitary authority.	Six Poor Law Medical Officers appointed ex officiis to be Medical Officers of Health, and ignorant of their sanitary duties. Board of Guardians imperfectly appreciating their functions as sanitary authority. District for the most part in a state of filth, with prevalences of enteric fever related to particular filthy conditions. Water supply generally exposed to risk of pollution from soakage of excremental and other matter.
24. North and South Tawton. (North Devon.) *Dr. Blaxall.*	Local complaint and outbreak of enteric fever.	Okehampton rural sanitary authority.	*North Tawton.*—Limited epidemic of enteric fever due to specifically contaminated water. Water supply derived from extraneous sources and from local wells, both exposed to dangerous pollution. Sewerage imperfect and irregular, house drains defective, inefficient ventilation of sewers and drains. Sewage discharged into watercourse and productive of much nuisance. Excremental nuisance general. Privies filthy and dilapidated. Nuisances from slaughter-houses, refuse, &c. *South Tawton.*—Insufficient water supply. No provision for drainage. Privy accommodation insufficient. Excremental nuisances rife.

* See footnote on page 26.

...of Inquiry and ...e of Inspector.	Ground of Inquiry.	Jurisdiction concerned.	Chief Facts reported by Inspector.
...rth and South ...wton—*cont.*	Local complaint and outbreak of enteric fever.	Okehampton rural sanitary authority.	*South Zeal* (a village in the parish of South Tawton).—Long continued prevalence of enteric fever. Wells exposed to dangerous pollution. A wholesome water supply could be easily obtained. Sewerage very imperfect. Privy accommodation insufficient. Excremental nuisances general. Refuse and manure stored near dwellings.
...tingham - ...ingham.) *Dr. Ballard.*	Information forwarded by Medical Officer of Health as to disease following the eating of certain meat.	Nottingham town council.	Fifteen persons taken ill with an acute specific disease after eating hot baked pork purchased at a particular "cook shop." One of these cases fatal. Symptoms and course of illness similar to those in the Welbeck series of cases reported on last year. Post mortem examination of the person who died revealed, *inter alia*, severe pulmonary haemorrhage and inflammation of ileum, and Peyer's patches and bacilli were discovered in the blood and various organs of the body. These bacilli produced, on inoculation into animals, similar morbid conditions to those produced by inoculations performed in the Welbeck case.
...n Rural Sani... District.* ...shire.) ...n, 11,181. *...Parsons.*	As to Medical Officer of Health arrangements.	Ruthin rural sanitary authority.	A sparsely populated agricultural district. No public works have been carried out, but a good many private nuisances have been abated, especially damp and unhealthy houses, and want of privy accommodation. New privies, however, rude and defective. Drainage deficient. Water supply insufficient and from sources liable to contamination. The Authority had been for a year without a Medical Officer of Health, and the present officer had only just commenced his duties at the time when the inspection was made.
...n Urban Sani... District.* ...shire.) ...n, 3,034. *...Parsons.*	As to Medical Officer of Health arrangements and action taken since former inspection.	Ruthin town council	Since Dr. Home's inspection in 1871 sewerage system has been completed, public water supply brought into general use, polluted wells closed, many unwholesome privies and cesspools altered, houses unfit for habitation disused and new ones of a better class erected. Sanitary administration on the whole good. Medical Officer of Health not under Local Government Board's order, and does not make annual report, but his duties seem to have been efficiently discharged.
...'s Chapel - ...wall.) *...Ward.*	Memorial from the Ratepayers as to insufficiency of water supply.	Tavistock rural sanitary authority.	Water supply situated at an inconvenient distance, and obtained from an open leat, which is fouled by road washings, cattle, &c., and exposed to casual pollution by human excrement.
...aph Rural ...* ...shire and ...ire.) ...n, 17,015. *Parsons.*	As to Medical Officer of Health arrangements.	St. Asaph rural sanitary authority.	The Sanitary Authority have constructed sewers and waterworks for several places in their district, and have under consideration similar works for other places in the district which require them. They have also been active in procuring the abatement of nuisances. Duties of Medical Officer of Health well performed, with the exception of delay in transmission of annual report to the Local Government Board.
...Rural Sani... ...rict. ...s.) ...n, 10,752. *...rry.*	Reports of Medical Officers of Health.	St. Ives rural sanitary authority.	The four District Medical Officers appointed Medical Officers of Health. Annual reports unsatisfactory. Performance of duties unequal. Sanitary progress slow.

* See footnote on page 26.

Area of Inquiry and Name of Inspector.	Ground of Inquiry.	Jurisdiction concerned.	Chief Facts reported by Inspector.
31. St. Mary Cray, &c. (Kent.) *Dr. Parsons.*	Report of Medical Officer of Health as to small-pox among rag-sorters.	Bromley rural sanitary authority.	Sudden and severe outbreak of small-pox among rag-cutters at a paper mill, probably attributable to infected rags, though there had been some previous cases of small-pox in the place with one of which some of the workers had been in indirect communication. (*See* page 108.)
32. Tavistock Rural Sanitary District. (Devonshire.) Population, 29,139. *Dr. Blaxall.*	Unsatisfactory working of the arrangements under which the District Medical Officers acted as Medical Officers of Health for their respective districts.	Tavistock rural sanitary authority.	Mortality greatly increased by dangerous infectious disease. Diphtheria and typhoid fever endemic with occasional severe epidemic outbreaks. Cottages not infrequently unwholesome by reason of being crowded, damp, ill-ventilated, or dilapidated. Water supply of certain villages good and plentiful, derived from extraneous sources. Other villages badly off for water, people having to fetch it from a long distance. Drinking-water exposed to pollution, often of a dangerous character. Streams polluted by privy contents. Excremental nuisances frequent. Sewerage and drainage very defective and imperfect. No means of isolation provided, and no efficient steps taken to prevent the spread of dangerous infectious disease. Neglect of Medical Officers of Health to make systematic inspection of their districts, with one exception, to make themselves acquainted with the provisions of the Public Health Acts.
33. Uckfield - - Population, 2,146. *Mr. Power.*	Local request on outbreak of enteric fever.	Uckfield urban sanitary authority.	Association of the fever with unwholesome conditions of water-supply, sewerage, and drainage. The subsoil stratum of soil covering the sandstone rock into which *the wells* are sunk generally befouled by soakage from privies, cesspools, ashpits, and defective drains. *Sewers* unflushed and practically unventilated, provided with catchpits that in the absence of manholes had never been cleansed. *House drains* generally unventilated and commonly in direct connexion with the sewers.
34. Walsall Rural Sanitary District. (Staffordshire.) Population, 8,502. *Dr. Thorne.*	Apparent faulty sanitary administration, as judged by imperfect reports of the Medical Officers of Health.	Walsall rural sanitary authority.	Rural district divided into three districts for the purposes of the appointment of Medical Officers of Health. The Rushall division exhibited grave sanitary defects as to sewerage, water supply, and excrement disposal, and an absence of any measures for their permanent remedy. Of the Pelsall and Bentley division much the same description may be given, and such action as had been taken had been limited to a removal of gross and recurring nuisances. In the Aldridge division many similar sanitary defects were discovered, but there was evidence that some useful sanitary work had been effected under the advice of the Medical Officer of Health. As to the whole rural district, it appeared evident that much of the sanitary neglect and the faulty sanitary administration was due to the division of the district between three Officers of Health, a division which had prevented the requisite personal conference between the authority and their adviser in sanitary matters which is secured where one officer is responsible for advice in regard to sanitary action.

Area of Inquiry and Name of Inspector.	Ground of Inquiry.	Jurisdiction concerned.	Chief Facts reported by Inspector.
35. Walton-on-the-Naze (Essex.) Population, 1,576. *Dr. Parsons.*	Reports of Medical Officer of Health as to sanitary condition of district.	Walton-on-the-Naze improvement commissioners.	Great want of potable water. Company's water brackish and unfit for dietetic use. Water for drinking brought in carts and sold at a high price. Sewers, drains and water-closets not flushed, and, until recently, unventilated; consequent escape of sewer air into houses. Outfall out of order. Prevalence of continued fever of a mild type in 1880, associated with defects of drainage. No building bye-laws. Newly-erected houses of bad design.
36. Williton Rural Sanitary District. (Somersetshire.) Population, 20,000. *Dr. Ballard.*	As to Medical Officer of Health arrangements.	Williton rural sanitary authority	In this district, having the largest area in Somersetshire, viz., 170 square miles, with about 20,000 population, the five Poor Law Medical Officers had been appointed *ex officiis* Medical Officers of Health at salaries little more than nominal. Not one of them had an adequate notion of his functions; some of them had been more active than others, but the work done was desultory and unsatisfactory in amount and character. It was ascertained by an inspection of the district that there was great need for administrative interference in respect of various matters, but especially of drainage and water-supply, and of the condition of labourers dwellings, matters on which the rural sanitary authority required to be advised broadly, as well as in detail, by a duly instructed and competent Medical Officer of Health, who could not, however, be expected to devote the necessary time and attention to his duties without proper remuneration.

APP. A. No. 5.

On the Animal Vaccination Establishment; by Dr. R. Cory.

No. 5.

On the EARLIER OPERATIONS of the ANIMAL VACCINE ESTABLISHMENT by DR. ROBERT CORY.

In July 1881, while search was being made for premises adapted to the standing wants of an Animal Vaccine Establishment, it was felt to be desirable that a beginning of operations should be made; such as should allow of lymph being produced on the calf and distributed to applicants, even if it did not permit of children being vaccinated direct from the calf at the place of lymph production.

Such an arrangement promised the further advantage of allowing selection to be made, without inconvenient delay, between the several available stocks of calf lymph; while it would enable experience to be gained as to manipulations of calves and other details of management.

Accordingly, premises were temporarily engaged at the workhouse of St. Mary Abbott, Kensington, in Mary Place, Walmer Road, Notting Hill. The yard of the workhouse and some buildings on it were not in use at the time; they were readily adapted to the housing of calves and their caretaker; and operations began here on July 21st.

History of lymph stocks used.

On that day calf No. 1 was vaccinated with animal lymph obtained from Dr. Carsten, of the Hague. The lymph was collected at the Hague from calves 1144 and 1146 on the 16th and 18th of July 1881 respectively. The vesicles produced by this lymph were not such as promised a satisfactory lymph stock, and a further supply was therefore obtained from Dr. Carsten. This second supply of lymph was taken from calves 1151 and 1153 at the Hague on the 31st July and 1st August 1881 and was used at Notting Hill for the vaccination of calf 4 on the 3rd of August 1881. The vesicles produced from this lymph were satisfactory. The lymph stock thus obtained was transmitted through a succession of calves, until the 6th March 1882, during which time 43 calves were vaccinated as shown in the following:

TABLE I.—Showing the Origin and Descent of the LYMPH, the WEIGHT, SEX, and COLOUR of the CALF, and the Character of the VESICLES.

Date of Vaccination and Number of Calf.	Origin and Descent of Lymph.	Weight of Calf. lbs. av.	Sex.	Colour.	Character of Vesicles.
1881.					
July 21 - Calf 1	Hague Calves 1144 and 1146.	No observations.	M	Red and white -	Indifferent.
„ 26 - „ 2	From calf 1 -		M	Do. -	Do.
Aug. 3 - „ 4	Hague Calves 1151 and 1153.		M	Do. -	Good.
„ 8 - „ 5	From calf 4 -	304	M	Do. -	Moderate.
„ 13 - „ 6	„ 5 -	310	M	Do. -	Indifferent.
„ 18 - „ 7	„ 6 -	296	M	Do. -	Do.
„ 23 - „ 8	Hague Calves 1151 and 1153.	308	M	Do. -	Good.
„ 28 - „ 9	From calf 8 -	270½	M	Red -	Good.
Sept. 2 - „ 10	„ 9 -	245	M	Red and white -	Indifferent.
„ 7 - „ 11	„ 10 -	213	M	Do. -	Moderate.
„ 12 - „ 12	„ 11 -	296	M	Do. -	Good.
„ 17 - „ 13	„ 12 -	257	M	Roan and white -	Moderate.
„ 22 - „ 14	„ 13 -	247	M	Red and white -	Indifferent.
„ 27 - „ 15	„ 14 -	312	M	Do. -	Good.
Oct. 2 - „ 16	„ 15 -	330	M	Roan - -	Moderate.
„ 7 - „ 17	„ 16 -	266	F	Do. -	Moderate.
„ 12 - „ 18	„ 17 -	303	M	Red and roan -	Moderate.
„ 17 - „ 19	„ 18 -	299	M	Red -	Good.
„ 22 - „ 20	„ 19 -	286	M	Do. -	Moderate.
„ 27 - „ 21	„ 20 -	362	M	Red and white -	Moderate.

Date of Vaccination and Number of Calf.	Origin and Descent of Lymph.	Weight of Calf. lbs. av.	Sex.	Colour.	Character of Vesicles.
1881.					
Nov. 1 Calf 22	From calf 21	383	M	Blue roan	Moderate.
„ 6 „ 23	„ 22	476	M	Red and white	Indifferent.
„ 11 „ 24	„ 23	317	M	Do.	Moderate.
„ 16 „ 25	„ 24	428	M	Do.	Good.
„ 21 „ 26	„ 25	206	F	Do.	Moderate.
„ 26 „ 27	„ 26	420	M	Do.	Very good.
Dec. 1 „ 28	„ 27	403	M	Red	Good.
„ 6 „ 29	„ 28	258	M	Do.	Very good.
„ 11 „ 30	„ 29	247	M	Roan	Good.
„ 16 „ 31	„ 30	201	M	Red and white	Moderate.
„ 21 „ 32	„ 31	262	M	Do.	Moderate.
„ 26 „ 33	„ 32	208	M	Black and white	Moderate.
„ 31 „ 34	„ 33	399	M	Red	Indifferent.
1882.					
Jan. 5 „ 35	„ 34	294	M	Red and white	Moderate.
„ 10 „ 36	„ 35	347	F	Blue	Very good.
„ 15 „ 37	„ 36	286	M	Red and white	Indifferent.
„ 20 „ 38	„ 37	296	M	Do.	Do.
„ 25 „ 39	„ 38	219	M	Black	Moderate.
„ 30 „ 40	„ 39	346	M	Red and white	Moderate.
Feb. 4 „ 41	„ 40	244	F	Do.	Very good.
„ 9 „ 42	„ 41	205	F	Do.	Good.
„ 14 „ 43	„ 42	239	F	Do.	Indifferent.
„ 19 „ 44	„ 43	198	F	Roan	Do.
„ 24 „ 45	„ 44	210	F	Red and white	Do.
March 1 „ 46	„ 45	280	M	Do.	Moderate.

The transmission was direct from calf to calf, and thus only, except as stated in the footnote.*

On the 6th of March, calf 47 was vaccinated on the left side from calf 46, and on the right side from some lymph obtained from Dr. *Du*breuilh of Bordeaux.

This lymph stock was discovered on the 26th of November 1881 at a farm in the village of Laforêt, not far from Bordeaux. It was brought to Paris by Dr. Dubreuilh of Bordeaux, who is the vaccinator of the Gironde. The results of the vaccinations done with this lymph are reported upon by Dr. Hervieux, in the "Gazette Hebdomadaire de Médecine et Chirurgie, 26th January 1882." The sample of this lymph stock, which was used for the vaccination of calf 47, was sent directly from Bordeaux by Dr. Dubreuilh to the Medical Officer of the Local Government Board. It was taken at Bordeaux on the 1st of March 1882, from the 17th calf vaccinated in succession from the discovery of the original or "spontaneous" case.

Calf 48 was vaccinated on the 11th March, on the right side, with lymph obtained from the vesicles produced on calf 47 by the new stock, and on the left side with that obtained from the vesicles produced by the old. As the new stock produced, markedly, the best vesicles, calf 49 was vaccinated entirely from the vesicles produced by it on calf 48.

Calf 50 was vaccinated entirely from a tube of Bordeaux lymph which had been reserved. It was vaccinated in 23 places, 20 of which were successful.

* Calf No. 3 was out of health and was not vaccinated at all.

It should be mentioned that, in addition to calves 1 and 4 vaccinated with Dr. Carsten's lymph, the following were not vaccinated from an immediately preceding calf, but with stored lymph taken as below:—No. 8 from Hague calves 1151 and 153 and calf 4; No. 11 from calf 8. Further, of calves vaccinated in succession, one after another with the Hague stock, the following were vaccinated both from the immediately preceding calf and also with stored lymph from one or more others as follow:—No. 7 from calves 4 and 5; No. 17 from calf 8; No. 21 from calf 19; No. 23 from calves 19 and 21; No. 24 from calf 21; No. 27 from calf 25; No. 32 from calf 29; No. 35 from calves 19, 28, 32; No. 38 from calves 31 and 36; No. 39 from calves 25 and 30; No. 44 from calf 42; No. 46 from calves 39, 40, 42.

APP. A. No. 5.

On the Animal Vaccination Establishment; by Dr. R. Cory.

The subjoined table, in continuation of the foregoing, gives other particulars of the calves vaccinated during March with this new stock. No. 51 was vaccinated from calf 50, and No. 52 from calf 51. Since March, and while this report is being written, a regular succession is being maintained in calf after calf with this same Bordeaux lymph-stock.

TABLE II.

Date of Vaccination, and Number of Calf.	Origin and Descent of Lymph.	Weight of Calf. lbs. av.	Sex.	Colour.	Character of Vesicles.
1882.					
March 6 Calf 47	Bordeaux calf -	192	F	Roan - -	Good.
„ 11 „ 48	See text above -	281	M	Red and white -	Very good.
„ 16 „ 49	From calf 48 -	281	M	Do. -	Moderate.
„ 21 „ 50	Bordeaux calf -	123	M	Do. -	Good.
„ 26 „ 51	From calf 50 -	134	F	Red - -	Very good.
„ 31 „ 52	„ 51 -	142	M	Red and white -	Excellent.

Observations on conditions affecting the development of the vesicles.

It will be seen by the above tables that a beginning has been made of observations on the weight, sex, and colour of the calves as affecting the development of the vaccination vesicles. The temperature of the stables has also been recorded since the beginning of the present year. The number of calves vaccinated is, however, too small to form a judgment upon the significance of these conditions, but as it is intended to continue the same observations during the coming year, it may be possible, at the end of that time, to draw a conclusion on some or all of the points in question.

General arrangements of the temporary station at Notting Hill.

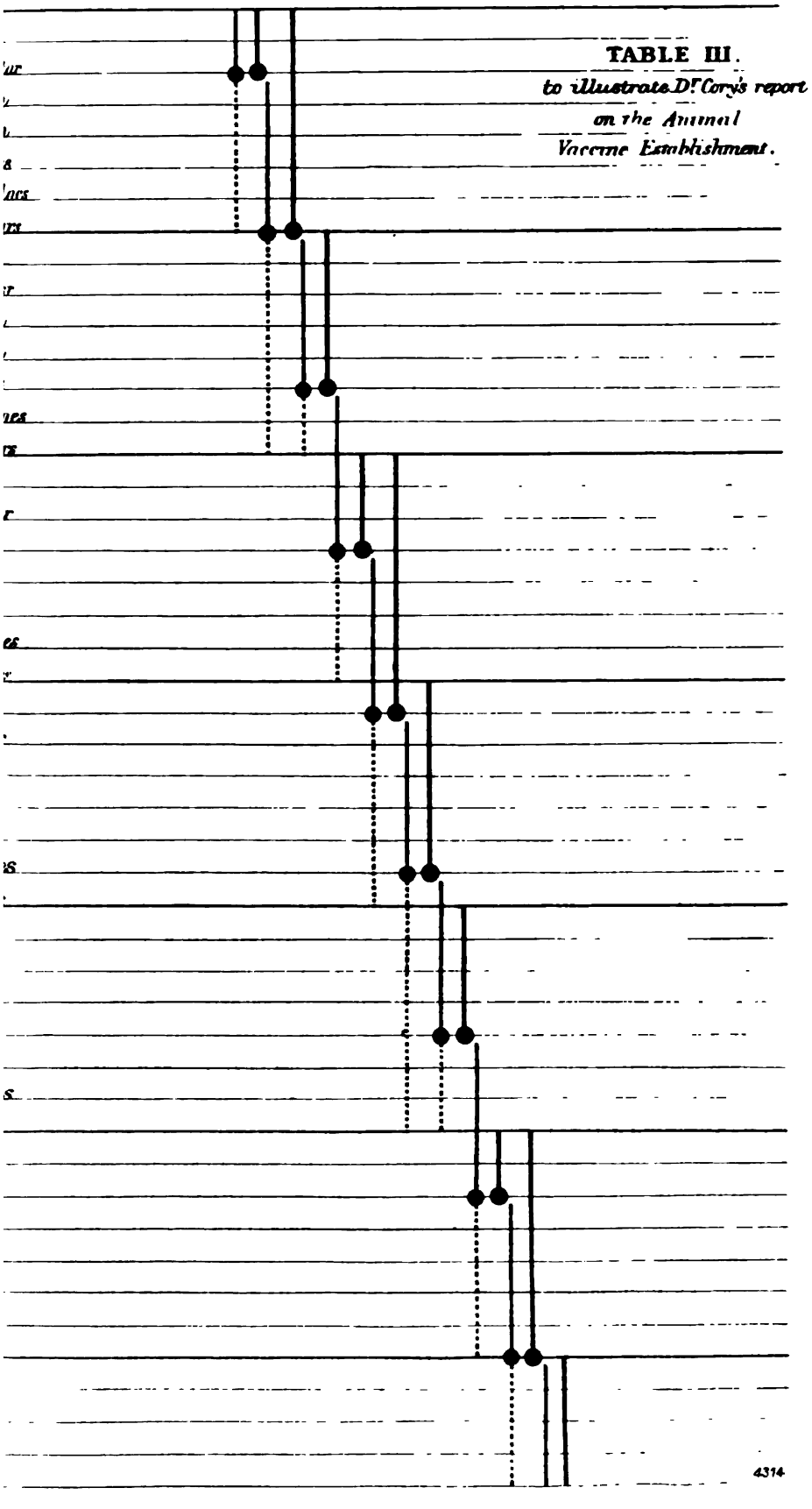
Two calves were always brought to the station on a Thursday. They were then placed in a shed by themselves until inspected by one of the veterinary inspectors of the Privy Council. They were then kept a variable time before being vaccinated, but never less than two days. The reason why the time was variable was, because the vesicles on the calf mature two days earlier than on the human subject, consequently to vaccinate directly from calf to calf, it is necessary to vaccinate every five days. The time the calves remained at the station varied from a fortnight to three weeks as will be seen from Table III.

The thicker black line across the table represents Thursday, the market day, on which calves were brought and taken away from the station. The perpendicular black line, terminating in the black dot, represents the interval during which the calf was retained at the station, before being vaccinated, the black dot is placed on the line representing the day on which it was vaccinated. The red line terminating in the red dot represent the five days occupied in the development of the vesicles, and the red dot is placed on the line when the lymph was taken and the next calf vaccinated. The interrupted red line represents the time the calf was retained at the station after vaccination.

It will be seen from this diagram that the week day on which calves were vaccinated from each other was continually changing. As there were no children at Notting Hill to be vaccinated direct from calf to arm, it was not necessary to arrange for the day of lymph-supply falling on an appointed week day.

Increase of weight of calves during their stay at temporary station.

The average length of stay of the 48 calves (whose weights were taken at the temporary station) was 18 days. During this interval they all increased in weight except one, and the average increase of weight of the 48 calves amounted to no less than 22 lbs. The average weight of each calf was 279 lbs. on admission, and 301 lbs. on leaving.



DANGERFIELD LITH 22 BEDFORD ST COVENT GAR

They were fed, the younger ones almost entirely, upon milk (two imperial gallons for each calf per diem), and the older ones, besides having the milk, had hay and oil-cake besides.

Food of calves.

Table IV. is drawn up to show the increase of weight gained by the lighter calves as compared with the increase of weight gained by the heavier ones. The numbers are not sufficient to draw any safe general conclusions, but as far as the evidence goes, it would appear that calves lighter than 225 lbs. do not thrive so well at the station as those which are heavier. A calf of about 225 lbs. weight would, as a rule, be about three months old.

Comparison of gain of weight between the lighter and heavier calves.

TABLE IV.

	No. of Calves from which Averages are taken.	Average Increase of Weight. lbs. av.
Calves under 200 lbs.	5	10·6
„ over 200 lbs., but under 225 „	7	18·2
„ „ 225 „ „ 250 „	5	27·2
„ „ 250 „ „ 275 „	5	30·
„ „ 275 „ „ 300 „	10	11·5
„ „ 300 „ „ 325 „	6	30·3
„ „ 325 „ „ 350 „	3	29·
„ „ 350 „ „ 375 „	2	34·5
„ „ 375 „ „ 400 „	1	21·
„ „ 400	4	32·

The following is a statement of the number of lymph-charges sent from Notting Hill and of characters of the lymph as observed by myself at the St. Thomas's Hospital vaccination station.

Lymph supplied.

Up to the 31st March 1882 1,352 charges of lymph were supplied from this station to the Local Government Board consisting of—

1,304 points.
47 tubes.
1 pair of glasses.

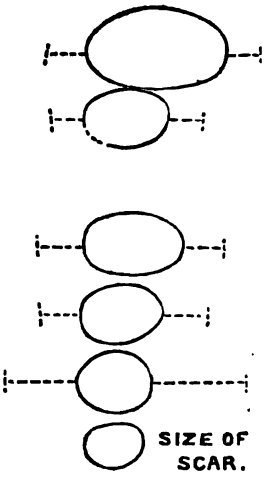
The very incomplete and ambiguous reports of the effects produced by the lymph that were made by the practitioners to whom it was sent, renders it impossible to gather any exact information from them; however, it would appear that the results with the old Hague stock were not satisfactory and that a marked contrast was observable between this stock and the new Bordeaux stock in favour of the latter.

Children vaccinated at St. Thomas's Hospital with preserved animal lymph.

Table V. (page 38) has been drawn up to show the results of vaccinations done with animal lymph preserved on points and tubes at St. Thomas's Hospital. They were all done by myself.

TABLE V.—Showing the RESULTS of VACCINATIONS done with kept ANIMAL LYMPH at ST. THOMAS'S HOSPITAL. Each Person was vaccinated in five places.

No. of Child on Register.	Date of Child's Vaccination.	Age of Child.	No. of Calf from which Lymph was taken.	Method of preservation of Lymph.	Amount of Lymph used.	Time Lymph was kept in Days before being used.	No. of successful Insertions.	The Ring drawn in Black Ink represents the average size of Vesicles; the dotted Lines represent the average Extent of Redness round parts on Eighth Day after Vaccination.
587	1881. July 27	§	No. 1	Points	2	1	1	
588	„	2 months	1	„	2	1	0	
589	„	5 „	1	„	2	1	4	
590	„	3 „	1	„	2	1	2	
*599	„	23 years -	1	„	2	1	3	
640	Aug. 24	3 months	7	§	§	1	0	
628	„	3 „	7	§	§	1	1	
646	„	3 „	5	§	§	10	0	
648	„	5 „	5	§	§	10	§	
31	1882. Feb. 1	3 „	36	Tube -	2	17	0	
32	„	3 „	36	Tube -	2	17	1	
†103	*March 15*	2½ „	47	*Points*	*1*	4	5	
104	„	5 „	47	*Points*	*1*	4	5	
105	„	3 „	47	Points	1	4	5	
106	„	3 „	47	Points	1	4	5	
108	„	3 „	47	*Tubes*	½	4	5	
109	„	2½ „	47	*Tubes*	½	4	5	
‡110	„	2½ „	47	Tubes	½	4	3	
111	„	2 „	47	Tubes	½	4	0	



* Case of re-vaccination.

† Calf 47 was vaccinated on the right side with the Bordeaux lymph obtained from Dr. Dubreuilh, and on the left side with the old Hague stock. The children numbered 103, 104, 108, and 109 were vaccinated with lymph collected from the right side of the calf (the new Bordeaux stock), and are printed in italics, whereas the rest of the children done on the 15th March were done from the lymph taken from the left side (the old Hague stock).

‡ Not inspected until the 20th May 1882. When the scar is examined during the first six months after vaccination the size of the scar is, as a rule, about the size of the vesicle on the eighth day.

§ In these cases the facts are not recorded. Vaccinated child 648 did not return for inspection.

No. 6.

Memorandum issued by the National Vaccine Establishment with Supplies of Calf Lymph.

Calf-Lymph Vaccination.

The present lymph is sent for the commencement of a local series of *arm-to-arm* vaccinations. In using it for this purpose, it is to be remembered—

(1.) *That, as compared with humanized lymph, calf-lymph is much less easy of removal from the "points;"*
(2.) *That such lymph does not "take" with the same degree of certainty as humanized lymph;*
(3.) *That the course of the early vaccinations of a series is not so regular as with humanized lymph.*

Any child chosen for vaccination with the lymph now sent, should be between three and five months old, and should be selected for its own good health and for the known good health of its parents. Two large points are needed for the vaccination of a single child. The lymph on them should be moistened for a minute with water, and should then be thoroughly rubbed into each of four or five places prepared on the child's arm or arms. Each of these places should be made by abrasion with a blunt lancet over an area of an eighth of an inch square.

In vaccinating subsequent children, lymph should be taken from fully developed vesicles, before the formation of an areola round them. The vaccination of the first child is liable to be retarded, and that of the next few children is frequently accelerated; so that it is desirable to inspect the several vaccinifers on other days beside the day-week, in order that the best time for taking lymph may be assured.

Calf-lymph for the vaccination of children is best preserved on points; but if it is desired to establish local series of *calf-to-calf* vaccinations, lymph in tubes or between glasses is to be preferred. Special application to the National Vaccine Establishment should be made, if lymph stored in either of the latter ways is desired. One or more perfectly healthy calves of four to five months old should be in readiness at the time of making the application.

August 1881.

No. 7.

App. A. No. 7. Memorandum on Small-pox in London; by the Medical Officer.

EXTRACTS from a MEMORANDUM by the MEDICAL OFFICER on the PREVALENCE of SMALL-POX in LONDON among VACCINATED and UNVACCINATED PERSONS respectively. (Addressed to the President, June 3, 1881.)

IT is just a twelvemonth since the Registrar General began systematically to record what he could learn about vaccination in the case of deaths registered in London from small-pox, and it may now be useful to take account of the facts and their meaning. The Registrar General tells us that he only returns as "vaccinated" and "unvaccinated" such cases of small-pox as are so certified by registered medical practitioners. Experience of the inaccuracy of the statement, excepting when thus certified, had rendered this limitation necessary.

The facts about vaccination in Londoners dying of small-pox are stated in the case of not quite two-thirds of the deaths registered; they are not stated in the case of rather more than a third of the registered deaths. It is to be regretted that the latter proportion is so large. The great bulk of the fatal cases among persons whose vaccination is "not stated," had certainly been attended by medical practitioners. Yet, through the qualified attendant having omitted to record the facts about vaccination, room is left for dispute whether the proportion between the cases certified as vaccinated and not vaccinated would be altogether the same, if the "not-stated" cases were taken into account.

I am going, in this memorandum, to regard the deaths among persons whose vaccination is not recorded (the "not-stated" deaths) as having occurred among vaccinated and not vaccinated in the same proportion as the deaths of persons where the fact of vaccination was recorded. Some people will be ready with their opinion, that a disproportionate number of "not-stated" deaths were of persons who had really been vaccinated; though, they would say, medical practitioners chose not to record a fact that told against vaccination. But there is no more reason for charging medical practitioners with reticence on one than on another ground; and it might just as well be suggested that they did not care to record a disobedience to law on the part of their patients, and that therefore it was chiefly in the case of those who died unvaccinated, that they would omit to state the facts about vaccination. Accordingly, I propose to set aside the "not-stated" deaths altogether; being satisfied, as I think any candid mind must be, that a fair approximation to the truth, about the *comparative rates of small-pox deaths in vaccinated and unvaccinated* may be got from an examination of the deaths that are "certified" to have taken place in the one and in the other class respectively. The *absolute* death-rate of the year in the two classes respectively cannot, of course, be measured unless the "not-stated" class were included in the calculations.

I propose that my consideration of the Registrar General's groups of figures shall deal, in the first place, with the small-pox mortality of all ages; next, with the mortality of people under 20; and, thirdly, with the deaths of children under five years of age.

Of people living in London at all ages, there died of small-pox during the past 52 weeks, 1,532; and of these, 325 are certified to have been

vaccinated, and 637 not to have been vaccinated; while the facts about vaccination are not stated in the case of 570 of the deaths.

Now, no one thinks of disputing that the population of London at all ages is made up by very unequal numbers of vaccinated persons and of unvaccinated, and the only question is how much larger one class is than the other. Estimates, made originally, I believe, by Dr. Seaton, but at all events stated by the Metropolitan Asylum Board in 1872, and adopted by the Registrar General in his Report upon the year 1871, have given the vaccinated as 19 times more numerous than the unvaccinated, and the estimate cannot be far wrong. On this showing, the present (unrevised census of 1881) 3,810,000 inhabitants of London divide into a vaccinated class numbering 3,620,000, and an unvaccinated class numbering 190,000.

Applying the mortality from small-pox at all ages during the last 52 weeks to these populations, we obtain as *the rate of small-pox mortality for the twelvemonth*, among the vaccinated class, 90 per million, and among the unvaccinated class 3,350 per million. These rates are for the inhabitants of London at all ages, and, as I have said, they are not absolute rates, but they are rates that admit of comparison one with the other, and as such they are approximately correct.*

I now pass to the consideration of the corresponding facts respecting persons under 20 years of age living in London.

The Registrar General's returns for the past 52 weeks show 874 persons under 20 to have died from small-pox. Of these, 94 are known to have been vaccinated, 475 are known not to have been vaccinated, and the facts about vaccination are "not stated" in respect of the remaining 305.

Now, the population of London under 20 was 1,398,048 in 1871, and this is computed to have increased during the past 10 years to some 1,640,000. What proportion of these are vaccinated and what unvaccinated? The answer to this question may be derived from the relative proportion of the two classes found in 1863 upon an examination of 3,185 children in various national, charitable, and parochial schools and workhouses of London. There were then 6·4 per cent. of children who had no vaccination scar, or whose vaccination scars were doubtful; and the remaining 93·6 per cent. of children had scars of successful vaccination upon their arms. With the machinery of vaccination officers commencing in 1867, and regularly at work since 1871, it is not to be supposed that this per-centage of unvaccinated has become greater, or the percentage of vaccinated less. Dividing the number of persons under the age of 20 now living in London, in accordance with these percentages, we obtain 1,535,000 as being the number of the vaccinated class, and 105,000 as the number of the unvaccinated class.

Applying the mortality from small-pox among persons under 20 years of age during the past 52 weeks to these populations, we obtain as the *rate of their small-pox mortality* for the twelvemonth: among the vaccinated class 61 per million; among the unvaccinated class 4,520 per million. These rates are for the inhabitants of London under 20 years of age, and they again are not absolute rates, but are rates that

* If it could be imagined that all the "not-stated" deaths were of persons who had never been vaccinated, the respective rates of all-age small-pox mortality would become 90 for the vaccinated, and would become 6,350 for the unvaccinated. If, on the other hand, it could be imagined that all the not-stated deaths were of persons who finally had been vaccinated, the respective rates of all-age small-pox mortality would become 247 for the vaccinated and 3,350 for the unvaccinated. Neither of these assumptions is in any way to be justified, but they may be useful as showing the limits of conceivable error on the score of the "not-stated" deaths.

admit comparison one with the other, and as such they are altogether to be trusted.*

It now remains to tell the results of a like examination of the mortality of children under five years old living in London.

In 1871 the population of London of this age numbered 422,629, and this number (raised in the proportion that the annual number of births in London has increased) would be brought to 510,000 for the present time. How many of these are known to be vaccinated, and of how many is evidence of vaccination wanting? This question can be approximately answered by a little calculation, based on the vaccination officers' returns. At the end of the first twelvemonth or so after birth (when the returns are made up) one in every twelve of the children born in London have died; and of those remaining alive, 91 per cent. are certified to have been vaccinated, the other 9 per cent. having either had small-pox, or having been reported insusceptible of vaccination, or having had their vaccination postponed, or being unaccounted for as to their vaccination. Ninety-one per cent., then, of the London population under five will represent the number of such population living at a given time who get vaccinated in the first year or so after birth, and it amounts to the number 464,000 out of the 510,000. Between this time of London children's lives and their fifth year of life, several hundreds, not far from a thousand, get vaccinated annually at public vaccinating stations, and about an equal number get vaccinated by private vaccinators.

Adding on this account 5,000 only, to get an estimate of the vaccinated population of London under five years of age, we obtain the number 469,000 children of that age certified to have been vaccinated, and may take the balance of 41,000 as probably not vaccinated; the latter number including all the above groups of insusceptible, unaccounted for and the like, along with the children who are under the customary age for vaccination and the unvaccinated children of people who have come up to London from the provinces.

In the 52 weeks under review there have been in the London community 19 deaths among children under five certified to have been vaccinated, 244 deaths among children of that age certified not to have been vaccinated, and 138 deaths among such children whose vaccination is "not stated."

Reckoning the two first of these figures as rates on the numbers of London children now living, vaccinated and unvaccinated respectively, we obtain, *as the rate of their death from small-pox* during the past 52 weeks, 40½ per million among the vaccinated class, and 5,950 per million among the not-vaccinated class. These rates are for London children under five; and I repeat once more that they are not absolute rates (which would be higher for both classes), but they are rates which admit of being compared the one with the other as showing the relative mortality of the two classes, and as such they may be taken as correct.†

The foregoing may be summed up as follows:—

---

* Reckoning experimentally, as in the former note, all the "not-stated" deaths under 20 to the one and to the other class; if they are all placed to the account of the unvaccinated, the rates would become 61 among the vaccinated, 7,428 among the unvaccinated; or if they were placed to the account of the vaccinated, the rates would become 260 among the vaccinated, 4,520 among the unvaccinated.

† Repeating the hypothetical calculations of former notes; if all the "not-stated" deaths under five are placed to the account of the unvaccinated, the death-rate per million of vaccinated would be 40½, and that among unvaccinated would become 9,800; whereas, if they were all placed to the account of the vaccinated, the death-rate in vaccinated children would become 334, and the rate in unvaccinated 5,950.

'OMPARATIVE SMALL-POX DEATH-RATES among LONDONERS, VACCINATED and UNVACCINATED respectively, for the 52 weeks ended 29th May 1881.

Death-rate of People of subjoined Ages.	Per Million of each Age of the Vaccinated Class.	Per Million of each Age of the Unvaccinated Class.
! ages - - - - - -	90	3,350
ıder 20 years - - - - -	61	4,520
ıder 5 years - - - - -	40½	5,950

I proceed to consider what lessons are to be learnt from the above.

(*a*) As no one suggests that the vaccinated and unvaccinated classes e under conditions differing from each other in their influence on all-pox, unless it be this one condition of vaccination, it follows for rst inference that the vaccinated are much less liable to die of small-pox ın the unvaccinated.

(*b*) The second lesson is, that vaccination is not an absolute protection ıinst small-pox. In recording the present illustration of a quite nitted fact, it will be convenient that I should refer to the possibility lifference in the degree of protection afforded by vaccination now-a-s as compared with former times.

The College of Surgeons, in 1806, addressed circular letters to its mbers, asking their experience of the protective power of vaccination, from their replies the following was compiled and communicated by College of Surgeons to the College of Physicians. Vaccination had n been in use some six years, not more.—It is the Board of Curators) are speaking:—

"To such letters the Board have received 426 answers, and the following are the results of their investigation:

"The number of persons stated in such letters to have been vaccinated is 164,381.

"The number of cases in which small-pox had followed vaccination is 56.

"The Board think it proper to remark, under this head, that in the enumeration of cases in which small-pox has succeeded vaccination, they have included none but those in which the subject was vaccinated by the surgeon reporting the facts."

'e have here the case of surgeons, in all parts of the country, writing period when the ordinary rate of small-pox mortality of England perhaps about the same as that of London during the present emic. They are writing their experience of the vaccinations done hem six years before at the longest. The College, in printing this rience of post-vaccinal small-pox, expressly limits it to cases rring in the practice of the several vaccinators. It does not record t deaths, if any, occurred among the 56 small-pox attacks. We ot now-a-days get any return for comparison herewith, but having figures of the Registrar General for the past year before me, I see ason to doubt that a very similar ratio of small-pox attack would been reported if present medical practitioners could be questioned the amount of small-pox among those of their patients whom they themselves vaccinated during the six years last past.

or (*c*) the third lesson derivable from the figures above tabulated bearing upon the foregoing point) is that the degree of protection,

both actual and relative, afforded by vaccination, is greatest to people under five years of age; less when ages from birth to 20 years are examined; and still less when people of all ages are taken into the account. Thus the distance of time from the operation appears to be concerned with the degree of its protective powers.

The foregoing lessons from the Registrar General's returns are nowise new, but they are taught afresh by to-day's experience among our own-selves in London; and they would appear, therefore, to be worth bringing to the notice of people who are trusting to chance for the escape of their children and themselves from the distressing, disfiguring, and fatal disease of small-pox.

Londoners can, by availing themselves of one average vaccination, diminish the chances of their children dying of small-pox in the proportion of 146 to 1 for the first five years of their life, and the same vaccination serves to lessen, in the proportion of 74 to 1, the chance of their being killed by the disease before they reach the age of 20. After that age the vaccination in infancy is further reduced in its protective influence, for the difference in small-pox mortality between the unvaccinated and the vaccinated class through the whole period of life is as 1 to 37, a protection incomplete indeed, but obviously important for everybody to possess.

You will observe that I have not said a word on the need for a *second* vaccination of people after the age of infancy, but no question of re-vaccination is concerned in the foregoing general conclusions, nor to any appreciable degree in the tabulated figures. The evidence now appearing as to the diminished potency of vaccination to prevent persons of later age dying of small-pox is entirely in harmony with the abundant evidence which we possess of the great additional immunity from small-pox conferred by a second vaccination upon soldiers, sailors, postmen, persons employed in small-pox hospitals, and upon others; and, indeed, if we had nothing but the present figures before us, they must be regarded as pointing strongly to a need for repeating vaccination as age advances.

* * * *

No. 8.

MEMORANDUM, addressed to the MEDICAL OFFICER, on the EPIDEMIC of SMALL-POX in London during 1881, with special reference to its relation to PUBLIC VACCINATION; by DR. H. STEVENS.

THE periodic epidemic character which small-pox in the metropolis ...sumes about every fourth or fifth year again asserted itself in 1880, and ...now, at the beginning of 1882, passing away. Recrudescence of the ...isease commenced in the last quarter of 1880; it attained its highest ...ortality in the second quarter of 1881, from which time it declined ...til the last quarter of the year when the weekly small-pox death-rate ...d become less than the average of the previous 10 years.

The total deaths by small-pox in the year 1881 were 2,371 as shown Table A., which gives the mortality by this disease from the ...gistrar General's returns for the last 15 years; and of these 2,371, 945 ...longed to the south group of registration districts, 597 to the east ...oup, 500 to the north group, 204 to the west, and 102 to the central; were really extra-metropolitan. Thus it appears that two-fifths of ...e whole mortality belonged to the south, and one-fourth, or thereabouts, the east.

TABLE A.

QUARTERLY SMALL-POX MORTALITY IN LONDON.

Quarter.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.
- -	99	2,460	831	46	24	37	7	1,192	556	221	122	617
- -	118	3,241	582	37	10	17	26	828	618	140	144	1,014
- -	157	1,255	237	15	10	15	110	252	133	63	49	461
- -	584	980	131	17	12	6	592	272	109	34	160	275
AL YEAR -	958	7,876	1,781	115	56	75	735	2,544	1,416	458	475	2,371

...867-8-9, the annual mortality amounted to 1,332, 606, and 275 respectively, but the quarterly ...ity cannot be stated.

The following Table B. will more readily show for 1881 the pro...ion of mortality by the disease borne by each group of registration ...icts as compared with the population of each. Here, as in the ...ding Table, deaths occurring in hospitals are distributed according ...e localities whence they were brought. In Table B., 31 deaths ...ght into metropolitan hospitals from beyond the metropolis are not ...n into account.

TABLE B.

...ups of Metropolitan Registration Districts.	Populations of Groups.	Deaths by Small-pox.	Deaths per 10,000 of Population of Groups.
- - - -	668,993	204	3·0
- - - -	905,677	500	5·5
...l - - - -	281,793	102	3·6
- - - -	692,530	597	8·6
- - - -	1,265,578	945	7·4
Metropolis - - -	3,814,571	2,348	6·1

...ile it is of general interest to note from the above Table the ...e incidence of mortality in each group of districts, it must not be ...ten that many districts are comprised in each group, and that

App. A. No. 8.

Memorandum on Small-pox in London during 1881; by Dr. Stevens.

these districts differ much *inter se* in their vaccination, their density of population, and in other respects, so that the liability of the several districts to attack and death by small-pox cannot be inferred from the liability of the group. For instance, we have in the south group of districts Greenwich Union, having the largest death-rate on its population, and Lewisham, which stands almost at the other extreme, having nearly the least rate of mortality.

A somewhat more accurate, but still inexact estimate of the relative infectiveness of different parts of the metropolis will be formed by a consideration of the following Table C. in which the death-rate, in proportion to population in each union, is shown.

Table C.

Deaths by Small-pox in the Metropolis, 1881, showing Deaths per 10,000 of Population in each of the Unions and Parishes.

(In the Districts marked H, a Small-pox Hospital is situated. The Deaths in such Hospitals have been distributed according to the Unions or Parishes whence the Patients were brought.)

Unions, &c.	Population.	Acreage.	Population per Acre.	Deaths.	Deaths per 10,000 of Population.	Order of Small-pox Death-rate
Bethnal Green - - -	127,006	755	168	121	9·53	5th.
Camberwell H - - -	186,555	4,450	41	198	10·61	4th.
Chelsea - - - - -	88,101	796	110	31	3·51	20th.
Fulham - - - - -	114,811	4,003	28	45	3·91	17th.
George, St. - - - -	149,603	1,943	76	39	2·60	25th.
George, St., East - - -	47,011	243	193	42	8·93	6th.
Giles, St., and St. George - -	45,257	245	184	10	2·20	28th.
Greenwich H - - -	131,264	3,426	38	246	18·74	1st highest.
Hackney H - - - -	180,400	3,935	47	246	13·19	3rd.
Hampstead - - - -	45,436	2,248	20	6	1·32	30th lowest.
Holborn - - - - -	151,716	816	185	57	3·75	19th.
Islington H - - - -	282,628	3,107	90	130	4·49	15th.
Kensington - - - -	162,924	2,190	74	52	3·19	22nd.
Lambeth - - - - -	253,569	3,941	64	99	3·90	18th.
Lewisham - - - - -	73,314	11,436	6	17	2·30	27th.
London, City of - - -	51,306	668	76	16	3·11	23rd.
Marylebone, St. - - -	155,004	1,506	102	38	2·45	26th.
Mile End Old Town - - -	105,573	679	155	63	5·96	12th.
Olave, St. - - - -	134,586	1,503	89	112	8·32	7th.
Paddington - - - -	107,098	1,251	85	23	2·14	29th.
Pancras, St. - - - -	236,209	2,672	88	80	3·38	21st.
Poplar - - - - -	156,525	2,335	67	96	6·13	11th.
Saviour, St. - - - -	195,111	1,119	174	139	7·12	9th.
Shoreditch - - - -	126,565	648	199	183	14·45	2nd.
Stepney - - - - -	58,500	462	126	44	7·52	8th.
Strand - - - - -	33,514	403	83	19	5·66	13th.
Wandsworth and Clapham - -	210,397	11,488	18	101	4·80	14th.
Westminster - - - -	46,456	216	215	14	3·01	24th.
Whitechapel - - - -	71,350	378	188	48	6·72	10th.
Woolwich - - - -	80,782	6,500	12	33	4·08	16th.

After the epidemic of 1876–7 the inequalities of the incidence of the disease in the metropolis formed the subject of a communication from the Metropolitan Asylum Board, and comments were made in Parliament respecting the great and continued prevalence of small-pox in London as compared with other large centres of population in which the disease had not occurred for several years. And, finally, at the commencement of the late epidemic you referred it to me "to investigate "the relationship of the then recent recrudescence of small-pox to the "vaccination arrangements in the metropolis."

In compliance with your directions I gave you a short recapitulation of the facts I had gathered in the course of my inspection of public vaccination in the metropolis which led me to believe that our ex-

ceptional visitations of small-pox in the metropolis were to a considerable extent due—

1. To unprotected migrants from one to another union.
2. To unregistered or inaccurately registered infants who could not therefore be traced; and
3. To badly vaccinated children and adults, and unrevaccinated adults and adolescents. All these being of course in addition to a varying amount of default in infantile vaccination in each district.

Since then I have made careful investigation into the circumstances connected with each death by small-pox during the last year. Inquiries of this kind in respect of persons of adult and more mature age are of course difficult and must of necessity be very incomplete, and some of the evidence obtained is necessarily somewhat unreliable; but my chief endeavour has been to secure completeness as nearly as possible in the histories I have obtained with regard to the deaths by small-pox of all children of 15 years of age and under.

Of all those who have died at these ages I have very reliable records of: 1. their birthplace; 2, their length of residence in metropolitan unions, if not born in them; 3, the fact of whether or not they had been vaccinated; and, 4, if vaccinated, by whom the operation had been performed.

These particulars are recorded in a register in which the deaths are entered in the order of their occurrence, and consecutively numbered, so that now, reference can readily be made to each case, and the notes or documents relating to it can be produced for examination.

Some synoptical tables I have deduced from this register show:—

1. The deaths pertaining to each union that took place (*a*) in hospitals, and (*b*) at their own homes.
2. The deaths of persons who were natives of the union in which they died (or from which they had been removed to hospital), and the deaths of immigrants into the different unions to which their case was debited, and—
3. The condition as to vaccination of those who succumbed to the disease.

Table D., appended to the present memorandum (page 51), shows the number of deaths by small-pox that occurred in each of the metropolitan unions in the year 1881, classified as vaccinated, doubtful, and unvaccinated.

From that table it will be seen that the gross number of deaths counted to 2,379, including 31 among extra-metropolitan residents. Of these, 738 had been vaccinated, 348 were returned as doubtful in respect of vaccination, and 1,293 had not been vaccinated. It will be seen that more than half the small-pox deaths of London occurred among the unvaccinated, who form but a small minority of the population; that more than a third were among the vaccinated, and that no assurance could be obtained of the vaccination of the individuals in the case of rather more than one-seventh part of the deaths registered from small-pox.

These figures of course refer to deaths at all ages and of necessity embrace those adults who had only been vaccinated in early infancy and who had not renewed their protection by recourse to re-vaccination.

But of the total deaths, 1,125, or nearly one half,* occurred in children under 5 years of age and under, and of these the proportion of deaths unprotected occurred among vaccinated, unvaccinated, and "doubtful" was respectively about a sixth, above three-quarters, and about a seventeenth part of the total deaths.

---

*It will be remembered that one-half the deaths by small-pox formerly occurred among children of five years and under.

App. A. No. 8.

Memorandum on Small-pox in London during 1881; by Dr. Stevens.

Further, as experience has long shown the extreme variations in protective power of different qualities of vaccination, great care has been taken to ascertain by personal investigation the history and nature of each operation, in the case of persons dying of small-pox after vaccination. It was known that, if the experiences of 1881 were in harmony with the experience of other epidemics, well vaccinated persons would be found to have died of small-pox within the first 15 years of their life at an infinitesimally small ratio.

The result has fully justified the anticipation of experience. For although in respect of many of the deaths the precise quality of the vaccination could not be ascertained, that of the children who had been vaccinated by public vaccinators was found to be capable of clear recognition. And in the case of the several children who died of small-pox after public vaccination, I have the gratification of recording that very complete record of the circumstances of their vaccination was always forthcoming.

Now, of the 1,125 children of 15 years of age and under who died by small-pox during the year, 56 were reported as having been vaccinated by public vaccinators, and in the great majority of these cases I have secured what will, I believe, be considered on the whole as very fairly substantial reasons for their deaths apart from any supposed failure of protection by vaccination. As the result of diligent personal inquiry into the cases of these 56 children, I have to record that in some instances the operation had been performed after small-pox had a strong hold of the system; in others the child was at death's door by some other disease when infected by small-pox; while, in a few cases, the child (reported as vaccinated) was found not to have been vaccinated at all.

Of the 56 children under 15 years of age reported as having been vaccinated by public vaccinators it would appear that 22 had either not been done at all, not done by public vaccinators, or with exceptionally poor results, 13 had been vaccinated when small-pox was incubating, 13 died of other diseases than small-pox, of 7 no clear history was obtainable, and one appeared to have been fairly well vaccinated by a public vaccinator.

But it will be observed that the age of 15 is that at which re-vaccination is enjoined even to those who may have been well vaccinated in infancy; and, as it is known that a very large proportion of the children swelling the year's list of small-pox mortality had been very indifferently vaccinated, a greater interest will attach to a consideration of the position held in the death record by vaccinated children of an earlier age. Children of 10 years and under represent the only class of the community that can be taken as a fair specimen of the results of the improved administration of the Compulsory Vaccination Acts that has obtained since 1871. I have, therefore, in another appended Table, (E), abstracted from the more extended Table D the deaths that occurred in all children under 10 years of age, and to this I have added copious and precise notes of their condition as to vaccination or as to complication of diseases other than small-pox that may have contributed to their death.

From Table E. we find that of the deaths by small-pox of children under 10 years of age 125 had been vaccinated, 782 had not been vaccinated, and of 46 the vaccination was doubtful. These figures are relatively to the whole number of deaths, in the proportion of about one-eighth vaccinated, four-fifths unvaccinated, and one-twentieth doubtful. Moreover the gross number of deaths under 10 years will be found to form just 40 per cent. of the total small-pox mortality at all ages in 1881. This shows a marked improvement in the rate of infant mortality by small-pox; prior to 1871 children under five years of age

contributed between 50 and 60 per cent. to the total mortality by that disease; during last year's epidemic they formed only 28 per cent. of the mortality, and children up to 10 years (or double the age) contributed only 40 per cent. of the total small-pox deaths.

Of the 125 deaths by small-pox after vaccination of children under 10 years of age, 43 were reputed to have been vaccinated by public vaccinators, and 82 privately. In the course of inquiry it was found that of the 43 reputed to have been vaccinated by public vaccinators eight had either not been vaccinated at all, or the operation had been unsuccessful; then of the 35 left, 12 had been vaccinated too late, small-pox having got too strong a hold of the system when the operation was performed, and of the remaining 23 reported as having been vaccinated by public vaccinators, I believe the notes to Table E. will go a great way to satisfy most people that no failure of the protective power of vaccination could reasonably be alleged as a participator in the cause of death, except perhaps in one case.

Of the perfect accuracy of these notes there can be no possible doubt, having that I have in every case myself obtained the information by personal communication with parents, medical attendants, or other trustworthy witnesses.

As it may prove of interest to note separately the deaths that occurred in hospitals, and those that took place at the peoples homes, I have added another Table F. (page 55), in which the deaths are so divided. This table shows that while 1,557 deaths (including 31 extra-metropolitan cases) were recorded in hospitals; 822, or rather more than a third of the whole took place at their own homes. Of these numbers the deaths in hospital embraced 474 of vaccinated, 208 of doubtful, and 875 of unvaccinated persons; and of the persons who died in their own homes, 264 had been vaccinated, 140 were doubtful as to vaccination, and 418 had not been vaccinated.

From these figures it appears that of the deaths in hospital, nearly a third were among vaccinated persons, more than a half among unvaccinated, and about an eighth part among those whose vaccination was doubtful; while among those who died at their own homes, the proportion of unvaccinated was slightly less, but there were still more than one-half the deaths occurring among persons who had not been vaccinated.

In considering the foregoing statements and the tables on which they are founded, it is apparent that a considerable mortality by a very preventable disease has been again allowed; and attention will naturally be first of all attracted by the fact that nearly 78 per cent. of the young persons under 15 years of age, and 82 per cent. of those under 10 who died of small-pox met their deaths after omission for some reason to provide them with the large measure of safety which the law orders which the State provides for them. This would seem to imply either (1), faults in the machinery for the provision of vaccination, or (2), defective administration of that machinery—possibly both.

Another point that must attract attention is the comparatively large number of cases in which there was doubt as to whether vaccination had been secured or not. This extensive failure to discover whether vaccination had been performed or not obtains not only in respect of deaths occurring at the homes of the people, but in an almost equal degree in respect of deaths taking place in hospitals. The explanation of this circumstance in the case of hospitals largely consists in the practice of some resident medical officers to avoid calling a patient "unvaccinated," unless (in addition to any presumption from lack of marks) the non-vaccination is specifically admitted by the patient or his

friends. It seems not unreasonable to infer that these numerous cases of doubt include a considerable majority in which there had been no vaccination. At all events the practice of those medical officers must remove any ground for suggesting that the recorded mortality of the unvaccinated, however extravagantly in excess of that among the vaccinated, has been made to appear larger than it actually was.

With respect to the unvaccinated it is only fair to metropolitan vaccination officers to point out that a certain portion of the unvaccinated who died by small-pox were of so young an age as not to have yet come under the attention of such officers, and that about two-thirds of the whole number that had escaped vaccination and afterwards died from small-pox were people who had moved out of the union where they were born into the district where they became attacked by the disease. The deaths by small-pox in children of three months and under contributed nearly half the deaths that occurred among children under one year. These infants had not (or had barely) come under the attention of the vaccination officer. The deaths among them were 123, being 114 among children born in the district where they died, and 9 in those born in other districts. Thirteen children who died of small-pox in these early months are returned as having been vaccinated; but in all of these 13 cases the operation was done after small-pox had taken hold on their systems.

As respects the effect of moving population it is not to be wondered at that among older persons a minority were found to have been attacked by small-pox in their native union, seeing that few people live and die in the same locality. But from the appended Table G (page 56) some facts may be gained as to the migration of younger persons. Of children of 15 years of age and under, more than half were alien to the place to which their deaths were refefred. And of these children the vaccination officers of the district into which they moved would have, in most instances, no knowledge whatever.

But, while exonerating the vaccination officer from blame for the escape of so many vaccinable children, it must be noted that such escape was in numerous instances the outcome of the divers and too numerous local governments into which the administration of the Vaccination Acts in the metropolis is broken up.

A means adopted by many of the metropolitan unions for securing a greater completeness of vaccination was the institution of house-to-house visitations for the purpose of finding out and getting protected all unvaccinated children, and of advising adults not to neglect the advantages of re-vaccination.

But this procedure was not universal in the metropolis. The guardians of several unions neglected such precautions, and in this way afforded opportunities, of which they were probably unaware, for evading the provisions of the Vaccination Acts and for getting a needless prevalence of small-pox in their unions. People who are making it their business to arouse prejudices against vaccination have distributed handbills advising the removal of children from the district in which their birth was registered into other districts; and it is notorious that in order to avoid the scrutiny of the house-to-house visitors children have been moved into districts where the guardians would not carry out such a search, and thus hundreds of unvaccinated children have been allowed to remain to swell the mortality by the next small-pox epidemic.

In this regard it appears much to be desired that some uniform administration of the Vaccination Acts could be secured for the whole metropolis.

UNIONS.	Unvaccinated. Age. 1–5	5–10	10–15	15–20	20–30	30–40	40–50	50–60	Above 60	Total.	Grand Total.
Bethnal Green -	21	13	6	5	3	3	2	—	—	71	121
Camberwell -	21	17	8	2	12	13	1	4	—	103	198
Chelsea - -	1	1	1	2	3	3	1	1	1	17	31
Fulham -	2	3	3	2	3	2	2	—	1	22	45
George, St. -	3	1	4	3	3	1	1	1	—	19	39
George, St., East	5	3	1	3	4	2	—	—	—	22	42
Giles, St. and St. Geo	—	1	—	—	1	—	—	—	—	4	10
Greenwich -	44	31	4	12	14	12	9	2	1	159	246
Hackney - -	26	17	11	7	14	4	1	2	—	109	246
Hampstead -	—	—	—	1	3	—	—	—	1	5	6
Holborn - -	8	1	3	4	3	2	2	—	—	27	57
Islington - -	10	5	5	7	13	8	4	3	2	67	130
Kensington -	5	—	1	6	8	2	—	—	—	24	52
Lambeth - -	12	9	2	4	2	2	2	—	1	44	99
Lewisham -	—	1	1	2	1	—	1	2	—	9	17
London, City of	1	2	1	—	1	1	—	—	1	7	16
Marylebone, St.	6	3	2	3	5	—	1	—	—	21	38
Mile End Old Town	6	5	3	3	5	3	—	1	—	35	63
Olave, St. -	15	14	6	7	11	1	2	2	—	63	112
Paddington -	—	1	—	1	4	—	—	—	—	8	23
Pancras, St. -	6	13	1	5	6	4	2	—	—	44	80
Poplar - -	14	6	3	1	7	5	—	—	—	50	96
Saviour, St. -	30	20	10	3	10	5	2	1	—	97	139
Shoreditch -	49	24	7	8	9	4	2	—	—	117	183
Stepney - -	10	5	3	—	4	1	—	—	—	28	44
Strand - -	2	2	1	—	—	2	1	—	—	9	19
Wandsworth and Cla	15	12	3	6	4	2	2	1	—	51	101
Westminster -	1	—	1	2	1	—	1	—	—	7	14
Whitechapel -	8	11	3	1	2	1	—	—	—	31	48
Woolwich -	4	—	—	2	2	—	—	1	—	13	33
Extra Metropolitan	—	1	—	3	3	2	—	1	—	10	31
Totals -	325	222	94	105	161	85	39	19	8	1,293	2,379

TABLE E.

ERED MORTALITY from SMALL-POX in 1881 in LONDON among CHILDREN under TEN YEARS of age.

ren taken ill resident in n or Parish bjoined.	Total Small-Pox deaths under ten.	Figures of Col. 2 classified from Registers and Vaccination Officers' Inquiries.			Figures of Col. 5 classified from personal Inquiries.			Figures of Col. 6 classified from further personal Inquiries. (*See also notes.*)	
		Not vaccinated.	Vaccination cannot be stated.	Vaccinated.	Not vaccinated or did not take.	Vaccination private.	Vaccination public.	Vaccinated while incubating Small-pox.	'Other deaths (See notes.)
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Green -	65	52	9	4	—	1	3	1	2[a b]
ell - -	72	63	—	9	1	7	1	1	—
- -	6	5	—	1	—	—	1	—	1[c]
- -	11	9	1	1	—	1	—	—	—
St., Hanover	8	6	1	1	—	1	—	—	—
t., in the East	16	12	2	2	—	2	—	—	—
George, Ss.-	4	3	1	—	—	—	—	—	—
h - -	118	105	4	4	—	3	1	—	1[d]
- -	89	70	5	14	1	12	1	—	1[e]
ad - -	—	—	—	—	—	—	—	—	—
- -	16	13	2	1	—	1	—	—	—
- -	42	28	1	13	2	8	3	2	1[f]
on - -	9	7	—	2	—	2	—	—	—
- -	38	31	2	5	—	2	3	—	3[g h]
- -	2	2	—	—	—	—	—	—	—
City of	3	3	—	—	—	—	—	—	—
ue, St. -	17	10	1	6	—	3	3	1	2[h]
Old Town -	25	20	3	2	—	—	2	1	1[i]
- -	42	34	2	6	—	5	1	—	1[m]
on - -	4	3	—	1	—	—	1	—	1[n]
St. - -	30	26	1	3	—	2	1	1	—
- -	41	34	—	7	2	4	1	—	1[o]
St. - -	75	66	—	9	—	8	1	—	1[p]
h - -	105	87	5	13	1	9	3	1	2[q]
- -	21	20	1	—	—	—	—	—	—
- -	6	5	1	—	—	—	—	—	—
rth and n.	40	33	—	7	—	4	3	—	3[r s]
ter - -	4	2	1	1	—	1	—	—	—
pel - -	33	24	3	6	—	4	2	2	—
- -	15	8	—	7	1	2	4	2	2[t u]
tropolitan -	1	1	—	—	—	—	—	—	—
tals -	953	782	46	125	8	82	35	12	23

Table E (*continued*).

Notes of Cases stated to have been Vaccinated by Public Vaccinator.

(*a*) D. S., aged 4½ years (No. 897 in register), was stated to have been vaccinated by public vaccinator, though the name did not occur in his vaccination register. The mother stated that when the child was first taken ill she thought it was measles, and she was confirmed in her opinion by Dr. S———, whom she called in; but after attending five days he said it was small-pox, deciding (according to the mother's statement) by the presence of one spot on the bridge of the nose. In earlier life the same doctor had attended the child, stating that it was in the first stage of consumption.

(*b*) W. J. D., aged 4½ years (No. 891 in register), vaccinated by public vaccinator when three months old; but mother stated that it had only very small marks on the arm. She further stated that the child was ill four days, that it was attended by Dr. Miller, of Bethnal Green Road. Of this case Dr. Miller writes: "I should be most happy to give you any information "respecting the case you refer to; but I have neither attended the child nor yet any other "person at the address you mention, and furthermore I may state that I have not lost a small-"pox patient in the parish, so that you must have been misinformed." The mother further stated that the child was always thin and emaciated; but that it had had no particular complaint.

(*c*) C. F. P., aged seven months (No. 2096 in register). The mother stated that her baby was a "tiny weasely thing," and that the public vaccinator hesitated to vaccinate it; but as mother wished it he did; but it took very imperfectly. It only showed in three very small heads, and soon died away. She had had other children vaccinated, and "had seen a good deal," but never saw so poor an arm as her baby's.

(*d*) J. H., aged 10 years (No. 74 in register). Mother stated that he was a strong child until he took the small-pox. He was taken ill on Monday with sickness and pains in back; eruption appeared on Wednesday. Diphtheria appeared on Friday, and he died on the following Monday. Small-pox only lasted five days, and there were only five or six pustules.

(*e*) R. A. H., aged 1½ years (No. 1473 on register). Mother stated that child never had small-pox. Its vaccination was delayed on account of its health; it always was delicate. The child took measles in April, and had had inflammation of lungs, which never left him to time of his death. Three weeks after the measles a slight watery eruption appeared, there were less than a dozen spots about the body. Chest was very bad and Dr. Calpin called in, who said it was inflammation of the lungs, the result of measles and chicken-pox. The eruption got quite well, and, a week after, the doctor examined the child again carefully, and stated that it was suffering from inflammation of lungs. Then—in about a month—all the children had scarlet fever, and R. A. H. had it also. The lung mischief continued, and he died in about a week.

(*f*) G. C., aged seven years (No. 923 in register). Mother stated that after vaccination child's arm was rubbed, and on inspection no lymph could be taken from it. The people were living in the greatest squalor and poverty—scarcely any clothing. Mother gave as little information as possible. Father said the boy never had small-pox at all; and neighbours stated they believed death to have been caused by want of necessaries of life.

(*g*) A. L., aged 10 months (No. 489 in register). Mother stated that on inspection public vaccinator said it had taken very slightly, and that it should be done again soon. The arm took in only two places, and those very small. Mother "never saw such small marks."

(*h*) J. M., aged 4½ years (No. 2208 in register). Vaccinated the week after Bank Holiday, when only one vaccinifer was presented for inspection, and J. M. was the 13th done from the child, and the vaccination took only in two places.

(*i*) W. P., aged 10 years (No. 2228 in register). Mother stated that this was her youngest child, that she had been in very poor health for several years; that a week after the vaccination the child had sores on the head, for which she got hospital advice, and that he had two subsequent attacks of the head complaint. She believes her boy had four marks on his arm, but had no recollection of their character.

(*j*) E. D., aged four years (No. 1283 in register). Mother stated that she knew E. D. had only one vaccination mark on her arm, and she did not believe that she had small-pox at all. She had two small spots on face the size of pins' heads. The sanitary inspector when he called also disputed it being small-pox.

(*k*) L. D., aged two years (No. 1084 in register), was vaccinated at public station, but had only one mark on arm.

(*l*) J. B., aged nine years (No. 799 in register). No reliable evidence as to the child could be had. Parents could not be traced, and landlady of house where they lived knew nothing of them, or of the child's vaccination. The name is not to be found in the public vaccinator's vaccination register; and a brother who died of small-pox (No. 1117 in register) had not been vaccinated.

(*m*) G. H. M., aged two years (No. 899 in register). Mother stated that her child when vaccinated had what she called a "bad arm," and very large and distinct marks resulted. The child was taken ill with sore throat about 24th April 1881, and a red rash appeared on the following day. She took the child to a chemist, who pronounced the disease "scarlatina," and advised her to call in a surgeon. She then applied to a so-called "provident dispensary," the assistant from which attended the child, and he thought it was suffering from measles. Upon 27th April the child got convulsions and died, and the death was certified as "variola," not "scarlatina." The mother further stated that the child never had pimple, pustule, or any other rash than the red mottling of the skin previously referred to, and that after death the surface of the skin was as smooth as the day the child was born. The Medical Officer of Health, Mr. Browning, also writes that on seeing the notice of death by variola in his weekly return he once visited the house, examined the corpse of the deceased child in the presence of two witnesses, and satisfied myself (*a*) that this child never had small-pox or any complaint which could possibly be mistaken for that disease; (*b*) that no eruption of any kind existed on any part of its body; (*c*) that there was no small-pox then in that house, or in that street; (*d*) that the relatives indignantly denied that their child had small-pox, but said that it had had a "croupy cold"; (*e*) that death appeared due to lung disease. I may add that I caused the error to be corrected in my next report, and in that of the Registrar General."

(n) A. M. H., aged 10 years (No. 218 in register). Mother stated that this girl had been very poor health for more than two years. She had recently had a second attack of measles and then chicken-pox; and when taken with small-pox she was immediately removed to hospital on Thursday night, and she died the following Sunday morning.

(o) E. M. W., aged two years (No. 1275 in register) This child had only three very different marks of vaccination as the mother stated, though it had been attempted in four places. She moreover said that the child was strong and healthy until attacked by small-pox.

(p) A. N., aged eight years (No. 817 in register). Mother stated that the child was a very drowsy stout child, but that it was never laid up with illness. The vaccination took in only three places.

(q) J. Z., aged four years (No. 1971 in register). Mother stated that vaccination took very badly, so that none could be vaccinated from it. She thinks that child's distress at leaving home and her persistent resistance to the nurses who tried to feed her, were more the cause of her death than any small-pox she might have had.

(r) J. G., aged seven years (No. 1575 in register). Mother stated that her child's arm took only in three places. When the child went to hospital with small-pox had very few pustules on her, and in a week or so she got pretty well and got about, but in about a month she had diarrhœa and died. She was in hospital five weeks.

(s) W. M., aged one year (No. 624 in register). Mother stated that child's arm took in only one small place, and the doctor at the hospital said to mother, "You can just see a mark and that is all."

(t) F. C. B., aged 13 months (No. 1382 in register). Mother stated her baby was a fine child and did well up to about three months old when the mother took small-pox and went to Stockwell Hospital. The baby was nursed by her sister who put it on Swiss milk. When the mother came out of hospital she found her baby had declined very much, then it picked up a little until it began to teeth: she sought medical advice for it on three or four occasions. On one occasion it was so very ill that the doctor despaired of it, he said that teething was the primary cause of its illness. And although 13 months old when it died it had not got one tooth through; she stated further, "My child did not die of small-pox, it had some spots about the face only, they were not small-pox spots." Dr. McDonogh states: "It is my opinion that B.'s child died of teething."

(u) M. M. L., aged five years (No. 2360 in register). The mother stated that her child had bronchitis and whooping cough, which very much weakened her. The small-pox appeared slightly on Friday night, and the girl died on Monday morning. The doctor stated that whooping cough had killed her, that the small-pox was so slight it could not have proved fatal.

(v) K. C., aged five years (No. 870 in register). There is an error here that I cannot reconcile. Parents could not be found. Child died on 23rd April, and public vaccinator certifies to having vaccinated it on the 22nd, and inspected it on 29th April.

(w) C. M. C., aged 7½ years (No. 1082 in register). Mother stated that her son was vaccinated by public vaccinator, but was not taken back for inspection, as it took only in two very small places, which were not larger than pins' heads, and that they never got any larger.

1–5	Unvaccinated. Age. 0–1	1–5	5–10	10–15	15–20	20–30	30–40	40–50	50–60	Above 60	Total.	Total.	Grand Total.
12	14	9	3	2	4	1	1	1	—	—	35	57	121
10	12	11	2	1	—	2	1	—	—	—	29	70	198
1	2	—	1	—	—	—	1	1	—	—	5	10	31
2	—	—	1	—	—	—	—	—	—	—	1	6	45
3	1	—	1	1	—	—	—	—	1	—	4	10	39
5	2	—	—	1	—	—	2	—	—	—	5	8	42
—	1	—	—	—	—	—	—	—	—	—	1	4	10
25	21	19	11	—	1	2	2	2	—	1	59	91	246
21	17	5	4	4	3	4	1	1	1	—	40	92	246
—	—	—	—	—	1	—	—	—	—	1	2	2	6
5	3	3	1	—	—	—	1	2	—	—	10	14	57
4	10	6	1	—	—	3	1	1	—	2	24	54	130
3	1	2	—	—	—	1	—	—	—	—	4	13	52
8	4	4	3	—	—	2	1	—	—	1	15	31	99
—	—	—	—	1	1	—	—	—	1	—	3	5	17
1	—	—	—	—	—	—	1	—	—	—	1	3	16
5	—	1	1	—	—	1	—	—	—	—	3	10	38
4	7	2	1	1	—	2	—	—	1	—	14	25	63
11	4	4	3	2	2	2	1	1	1	—	20	39	112
—	1	—	—	—	—	—	—	—	—	—	1	7	23
4	6	2	3	—	1	—	1	—	—	—	13	27	80
4	13	10	2	3	—	2	2	—	—	—	32	60	96
20	8	10	6	1	1	1	1	—	—	—	28	43	139
35	7	14	8	1	1	1	—	1	—	—	33	59	183
8	3	2	1	1	—	3	—	—	—	—	10	12	44
2	1	—	—	—	—	—	—	—	—	—	1	5	19
9	3	6	1	—	1	—	—	—	—	—	11	35	101
—	—	1	—	—	—	—	—	—	—	—	1	4	14
5	—	3	2	—	—	1	—	—	—	—	6	9	48
1	4	3	—	—	—	—	—	—	—	—	7	17	33
—	—	—	—	—	—	—	—	—	—	—	—	—	31
08	145	117	56	19	16	28	17	10	5	5	418	822	2,379

VACCINAT	
1-0	
6	
5	
1	
1	
1	
4	
9	
2	
3	

VACCINATED.															
		Not Born in District.													
		Age.													
0–1	...	0–1	1–5	5–10	10–15	15–20	20–30	30–40	40–50	50–60	Above 60	Total.	Total.	Grand Total.
1	4	6	11	7	2	3	3	3	2	—	—	37	71	121
—	3	5	16	13	5	2	12	13	—	4	—	70	103	198
—	4	—	1	1	1	1	3	3	1	1	1	13	17	31
—	4	1	2	3	2	2	3	2	2	—	1	18	22	45
—	5	1	2	—	2	3	3	1	1	1	—	14	19	39
—	1	—	1	1	1	3	4	1	—	—	—	11	22	42
—	2	—	—	1	—	—	1	—	—	—	—	2	4	10
—	5	4	18	15	3	11	12	9	9	2	1	84	159	246
—	6	9	20	11	8	6	13	3	1	2	—	73	109	246
—	1	—	—	—	—	1	3	—	—	—	1	5	5	6
—	8	2	5	—	2	4	2	2	2	—	—	19	27	57
—	4	3	4	2	3	5	12	8	4	—	2	43	67	130
—	5	—	4	—	1	4	8	2	—	—	—	19	24	52
—	5	4	7	6	2	3	2	2	2	—	1	29	44	99
—	3	1	—	1	—	1	1	—	1	1	—	6	9	17
—	2	—	—	2	1	—	—	1	—	—	1	5	7	16
—	9	—	3	1	—	2	5	—	1	—	—	12	21	38
—	6	4	5	5	3	1	4	3	—	1	—	26	35	63
—	3	1	8	6	4	5	11	1	2	2	—	40	63	112
—	1	2	—	1	—	1	4	—	—	—	—	8	8	23
—	8	1	5	6	—	3	6	3	2	—	—	26	44	80
—	6	2	11	6	2	1	7	5	—	—	—	34	50	96
—	1	9	18	9	9	3	10	5	2	1	—	66	97	139
—	9	2	25	16	6	6	8	4	1	—	—	68	117	183
—	2	1	5	4	2	—	4	—	—	—	—	16	28	44
—	3	1	2	—	1	—	—	1	1	—	—	6	9	19
—	9	3	11	11	3	5	4	2	2	1	—	42	51	101
—	2	1	1	—	—	1	1	—	1	—	—	5	7	14
—	2	1	6	8	1	—	2	1	—	—	—	19	31	48
—	7	—	3	—	—	1	1	—	—	1	—	6	13	33
—	4	—	—	1	—	3	3	2	—	1	—	10	10	31
1	1	64	194	137	64	81	152	77	37	18	8	832	1,293	2,379

No. 9.

On a Case of "Sausage Poisoning" which occurred at Arlford, near Chester; by Dr. Ballard.

G. T., æt. 42, a gardener in the employ of the Duke of Westminster, and in his usual state of good health, had occasion to go into Chester, a distance of a few miles, which would occupy him about half-an-hour to drive, early on Saturday morning, March 13th, 1881. His wife says that he took with him for his dinner that day some bread and bacon, but on his return it was found that he had only eaten the bread, having brought home all the bacon he took out with him. While he was in Chester he purchased at a shop there about half-a-pound of sausage. He had returned to his work at the gardens at Eaton by 10.30 or 11 a.m., and his wife and other persons saw him there about that time quite well. He had nothing to do before noon but groom his horse, which he would do immediately on his arrival at the gardens. At about 11.45 he was seen by his son lying in the stable very ill, and he told his son that he had, since his return, eaten the food he had purchased in Chester. There is every reason then to believe that he ate the sausage after grooming his horse, an operation which would take about half-an-hour, namely, between 11 and 11.30 a.m. He had gone out in the morning without his breakfast, and it is not certainly known whether he had any other food in Chester. But as his appetite was shown to be good by his having eaten the whole half-pound of sausage, and as there is no evidence of his having purchased anything but the sausage in Chester, the probability is that he had not. Had he eaten anything, it would probably have been the bacon as well as the bread he had taken out with him.

When first seen by his son, and later by others, he was lying on the hay, and suffering from abdominal pain, which was so severe as to "double him up," and caused him to roll about in agony. He appears to have vomited early in the attack, and subsequently to have been purged. As the pain and sickness continued he became much prostrated. Persons who saw him say that his head was hot and his face flushed, while his feet were cold, and that he complained alternately of heat and dryness. At about 4 p.m. he was carried home to Arlford, lying groaning at the bottom of a cart, and was helped upstairs to bed. There was no evidence and there was no indication about him that he had been drinking. During the evening and night he continued to vomit and retch violently and also to be purged. The vomited matters at this time are said by his wife to have been watery and clear looking, and the purged discharges watery, brown, and somewhat, but not very, offensive. He was very thirsty. A medical man, Dr. Thelwall, saw him in the course of the evening, and gave him a stomachic mixture. He saw him again on the Monday morning. He says that then he was complaining of cough, soreness in the chest, and pain under the sternum, and that the sputa were rusty and glutinous. He gave him some saline aperient medicine, and later in the week some medicine containing antimony and opium. He says he considered that the man was suffering from bronchitis, and treated him accordingly. As the week went on he is said to have improved, but on Sunday, March 21st, his breathing became difficult, and he died in the course of the evening. The coroner

App. A. No. 9.

On a case of "Sausage poisoning" at Arlford, near Chester; by Dr. Ballard.

refused to hold an inquest, so that as the body had been buried, no *post-mortem* examination was made.

I discovered on inquiry, in which I was assisted by Dr. Kenyon, the Medical Officer of Health for Chester, that the portion of sausage eaten had been cut from a sausage of a new consignment of similar sausages which were of American manufacture. Immediately on the man's illness becoming known, the rest of the consignment was set aside and not sold. Several of the sausages, including that one from which G. T. had been served, were given over to Dr. Kenyon, who, at my request, forwarded portions of each that he had to Dr. Klein for experiment.

The sausages were of a large description, similar to those commonly sold under the name of "German sausages," and weighing each several pounds. Each sausage was imported packed into a cylinder of tinned iron, the interval between the sausage and the cylinder being filled in with melted fat. The covers of the cylinders were soldered down. The sausages were said to have been made of beef. On rough examination they appeared to consist of some kind of cooked flesh mixed with pieces of raw pork fat, the whole being seasoned and coloured with red oxide of iron. On chemical examination no other mineral substance was discoverable. The freshly cut surface had no unusual odour.

No similar case of illness was heard of either in Chester or its neighbourhood. The vendor of the sausage told me that a cat of his had eaten part of the same sausage as G. T., and was not taken ill.

The following is Dr. Klein's report of the experiments which he made:—

"The sausages were marked 1, 2, 3, 4, 5, 6, 7, 8, 9. No. 9 was the remains of the sausage which G. T. had partaken of.

"These sausages were used for feeding animals—rabbits and mice. While some samples (Nos. 7 and 5) proved innocuous, others (Nos. 6 and 8) were very poisonous.

"With No. 6 were fed 12 mice and 4 rabbits. Of the mice, five died spontaneously (three after 24 hours, and two after 60 hours), three were killed while ill, and four escaped illness. Of the rabbits, one died spontaneously during the first day, one during the second day, and the two others were killed while ill.

"With No. 8 were fed four mice. Of these, one died spontaneously after eight hours, one after 30 hours, and the other two after 24 hours.

"On March 26, four rabbits and four mice were fed with No. 9 (the sausage G. T. had partaken of), and none of these animals suffered illness. On May 2, however, four mice were fed with it, and became ill; but they had recovered perfectly on the fifth day.

"In all instances where the animals became ill, *the illness showed itself very soon after the feeding*, viz., from a quarter of an hour to several hours. The animals became very quiet, and in some instances, especially in the rabbits, there was vomiting a quarter of an hour after feeding; they did not take their food and did not care to move, their faces became pinched and their eyes small. In the case of the mice their coats became very rough. This state soon grew worse, the animals becoming comatose, the temperature rapidly sank, and the animals soon died. In some cases they lingered on for several days, recovered slightly, took food again, and became a little more lively; but when killed they showed the same post-mortem appearance as those that died spontaneously, only in a milder degree.

"On post-mortem examination the appearances found were, *hæmorrhage in the stomach*, congestion of the lungs, enlarged kidneys, the cortex of the organs being pale, the medulla hyperæmic. On micro-

scopical examination of the kidney, the important fact was ascertained that *most of the urinary tubules contained casts*, that many Malpighian corpuscles and the tissues surrounding them were *in a state of disintegration*, without, however, there being present any inflammatory cells (pus-corpuscles), so that this disintegration was evidently the *direct result of some destructive agency* circulating in the vessels of the glomeruli of the Malpighian corpuscles.

"The result of these experiments was then in a high degree indicative of the presence in the sausages of some chemical poison, for the *sudden* illness following shortly after the feeding, the vomiting, the hæmorrhage in the stomach, and the condition of the kidney are just such as to be compatible only with that assumption.

"Consequently, part of sausage No. 6 (which had proved very poisonous to mice and rabbits) was forwarded to Dr. Dupré, and he prepared from it, *a*, a cold alcoholic extract, and, *b*, an alkaloid (in an impure state). Experiments, however, made by feeding and inoculation with either of these on a dog, two mice, and two rabbits did not produce any symptoms of illness."

There is no necessity to add many remarks to this statement by Dr. Klein. The bearing of his experiments upon the fatal illness of G. T. is obvious. The man, like the animals, was speedily attacked after eating the sausage, his first symptoms being those of gastro-intestinal irritation, which after a time passed off, only to be followed by a secondary illness, one condition of which was obviously pneumonia, a common result of renal mischief.

It would appear from Dr. Klein's experiments that the poison was not equally diffused through the sausages, since some of the sausages were innocuous, and portions of the same sausages that produced illness in some animals were eaten by other animals with impunity. This fact lessens the significance of the negative results obtained by feeding and inoculating animals with the matters prepared chemically from a portion of one of the sausages by Dr. Dupré.

To such persons as have read my reports to the Board on the series of cases of diarrhœal disease which occurred last year at Welbeck, and this year at Nottingham,* the record of this case will be specially interesting. While in all three instances gastro-intestinal symptoms of a severe character were at the first the predominant phenomena, the points of contrast in respect of an incubation period in the Welbeck and Nottingham cases, and of sudden speedy illness in this case, and in respect of the post-mortem appearances, are too marked to escape notice. The present case is perfectly distinct from the others in its pathology. The Welbeck and Nottingham cases were illnesses produced by the growth and development in the system of a living thing. The illness in this case was a true poisoning by some organic chemical poison.

---

* See page 36 of the Medical Officer's Report for 1880 (First Supplement to the Tenth Annual Report of the Local Government Board).

No. 10.

On an Epidemic of Scarlatina in Halifax; by Dr. Ballard.

The occasion of this inquiry was a memorial signed by several of the medical practitioners and a large number of other inhabitants of Halifax requesting an inquiry into the circumstances of numerous cases of scarlatina which had been reported in the town. Letters from medical men and from persons whose families had been invaded by the disease had also been received by the Board. Prior to the inquiry a special report upon the cause of the outbreak had been made to the Sanitary Authority by Mr. Ainley, the Medical Officer of Health, in which report he had attributed the outbreak to the distribution of milk from a farm outside the borough by a milkman who had at the time scarlatina in his family at home. Mr. Ainley said in his report, "This, beyond all question, was the cause of the outbreak." To this opinion exception was taken.

The inquiry was necessarily a protracted one, and I have to acknowledge the great and loyal assistance I received from all the officers of the Authority, and especially from the Medical Officer of Health, the borough surveyor, and the inspector of nuisances, throughout the investigation. Nearly half the number of the medical men practising in Halifax furnished me, at my request, with lists of the cases of scarlatina and scarlatinal sore throat that had occurred under their observation between November 1, 1880, and February 17, 1881.

The total number of cases in these lists amounted to 510, occurring in 281 separate families; but the entire number of cases that had occurred and families invaded between these dates would probably have been found very much larger, perhaps twice as large, had all the medical men furnished me with lists, and had it been possible to include all the cases attended by irregular practitioners or unattended during illness. The epidemic was fading away when the inquiry commenced. One death from the disease occurred in November, 5 in December, 52 in January, and 28 up to February 25.

The following tables show the distribution in weeks of the cases reported to me by the medical men who sent in lists and of the above-mentioned deaths. The cases and deaths are also distributed among the wards into which, for municipal purposes, the borough is divided:—

Table 1.

Cases of Scarlatina and Scarlatinal Sore Throat.

Weeks ended.	Wards (for Population *see* Table 3).										Total Cases.	Families invaded.
	Ovenden.	Northowram.	North.	Central.	West.	South.	Market.	East.	Southowram.	Skircoat.		
1880, November 6	—	—	—	—	—	1	1	—	—	2	4	4
" " 13	—	—	—	—	3	1	1	1	—	2	8	5
" " 20	—	—	—	1	1	4	—	1	—	—	7	5
" " 27	—	—	—	—	2	—	—	—	—	—	2	1
" December 4	—	—	1	—	—	3	—	—	—	—	4	3
" " 11	—	—	—	—	—	—	—	—	—	—	0	0
" " 18	—	—	—	—	—	4	—	—	—	1	5	3
" " 25	—	—	1	—	—	6	—	—	—	—	7	3
1881, January 1	—	—	—	2	2	14	—	—	—	—	18	12
" " 8	—	—	—	—	4	75	—	—	—	4	83	27
" " 15	—	1	—	7	38	125	9	1	—	7	188	94
" " 22	1	—	1	2	13	24	—	—	1	1	43	24
" " 29	—	—	—	2	18	58	1	1	—	—	80	42
" February 5	—	—	1	1	10	18	—	—	—	—	30	21
" " 12	—	—	—	1	3	9	1	—	—	—	14	10
" " 19	—	—	1	—	8	3	2	—	—	1	15	9
" " 26	—	—	—	—	—	2	—	—	—	—	2	1
Totals -	1	1	5	16	102	347	15	4	1	18	510	281

Table 2.

Deaths from Scarlatina.

Weeks ended	Wards.										Total Deaths.
	Ovenden.	Northowram.	North.	Central.	West.	South.	Market.	East.	Southowram.	Skircoat.	
1880, November 6 -	—	—	—	—	—	—	—	—	—	—	0
" " 13 -	—	—	—	—	—	—	—	—	—	—	0
" " 20 -	—	—	—	—	—	—	—	—	—	—	0
" " 27 -	—	—	—	—	—	—	—	—	—	—	0
" December 4 -	—	—	—	—	1	1	—	—	—	—	2
" " 11 -	—	—	—	1	1	—	—	—	—	—	2
" " 18 -	—	—	—	—	—	1	—	—	—	—	1
" " 25 -	—	—	—	—	—	—	—	—	—	—	0
1881, January 1 -	—	—	—	—	1	1	—	—	—	—	2
" " 8 -	—	—	—	—	—	2	—	—	—	—	2
" " 15 -	—	—	—	—	4	9	—	1	1*	—	15
" " 22 -	—	—	—	—	4	9	—	1	—	2	16
" " 29 -	—	1	—	—	4	7	—	—	—	—	12
" February 5 -	—	—	—	2	2	5	—	—	—	—	9
" " 12 -	—	—	—	—	3	7	—	—	—	—	10
" " 19 -	—	—	—	1	1	6	—	—	—	—	8
" " 26 -	—	—	—	—	3	3	—	—	—	—	6
Totals - -	0	1	1	4	24	51	0	2	1	2	86

* In Borough Hospital.

1. It is obvious from these tables, whether regard be had to the distribution of the reported cases of scarlatinal illness or of the deaths from scarlatina, that the epidemic was chiefly incident upon two adjoining wards, namely West and South wards, and especially upon the latter, although it did not spare altogether other and more distant parts of the borough. It also spread to families residing outside the borough.

2. It is further obvious that although cases of the disease had been under medical observation in the borough during the months of November and December, a remarkable extension of the disease, apparently indicating the operation of some special influence, took place in the last week of 1880 and the first week of 1881, and that this special influence was exerted chiefly in South and West wards.

The chief object of the investigation therefore was to discover the nature of this special influence, and as nearly as practicable the precise extent of its operation, holding in view the operation of other ordinary causes of epidemic spread. That, in a very large degree, the disease did spread by the ordinary methods in which infectious diseases spread, such, for instance, as personal and family communication and visiting, became perfectly clear from the inquiries which were made.

I may add that, so far as I have been able to ascertain by inquiry, the epidemic affected families of all classes and ranks in life. Out of the 281 families embraced in the lists forwarded me by the medical men, 106 were families of gentry and the upper class of tradesmen, the remaining 175 being families of small shopkeepers, artizans, mill-hands, labourers, &c.

The following table, constructed from data furnished me by the Medical Officer of Health, shows the mortality from scarlatina in the borough and its several wards during six years, 1875 to 1880 inclusive.

TABLE 3.

Years.	Wards (Population, 1871).										
	Ovenden. Population, 4,327.	Northowram. Population, 7,069.	North. Population, 5,650.	Central. Population, 8,801.	West. Population, 10,549.	South. Population, 7,668.	Market. Population, 4,086.	East. Population, 6,304.	Southowram. Population, 6,119.	Skircoat. Population, 6,187.	Whole Borough. Population, 65,910.
1875	9	6	3	6	9	10	5	6	11	1	66
1876	1	2	3	1	3	4	—	2	1	—	17
1877	10	17	22	13	21	26	7	7	13	24	160
1878	5	11	6	1	12	4	3	1	11	4	58
1879	17	13	7	24	23	18	5	3	4	11	125
1880	4	13	3	1	7	10	—	1	—	5	44
Totals	46	62	44	46	75	72	20	20	40	45	470
Per 1,000 of population	10·6	8·7	7·7	5·2	7·2	9·3	4·8	3·1	7·8	7·3	7·1

From which it appears—

1. That during these years (least in the year 1876) scarlatina has been fatally prevalent in the borough year by year, and in some years, notably in 1877 and 1879, exceedingly prevalent and fatal.
2. That taking all the six years as one period, the mortality from the disease has been, compared with the population (1871) of the

several wards, greatest in Ovenden, South and Northowram wards, next greatest in North, Southowram (containing the borough hospital), Skircoat, and West wards, and that it has been least in Central, Market, and East wards.

3. That the chief incidence of the mortality has fallen upon different wards in different years or different epidemic periods, South and West wards having by no means been the wards upon which it has habitually fallen. No doubt accidental circumstances, which cannot now be ascertained, have, in these different periods, determined the locality of principal incidence. This fact gives point to the question, why, in the epidemic now under consideration, South and West wards were those in which the disease chiefly spread? Has there been any special circumstance capable of accounting for its extension in these wards in preference to other wards?

The reply given to these questions by the Medical Officer of Health is involved in his opinion as to "the cause of the outbreak." Some of the medical men who signed the memorial, and with whom I conversed upon the subject, while repudiating the inference of the Medical Officer of Health on the ground that the disease was present in the borough prior to the appearance of scarlatina in the milk carrier's family, were, I gather, disposed to attribute the epidemic extension in South and West wards rather to faults of administration on the part of the Sanitary Authority, and mainly to imperfect and improper arrangements of drainage and sewering. It was asserted that these are the wards which have suffered most on each occasion of epidemic extension of scarlet fever, and that these are among the localities where most of the new houses have been erected ostensibly under the supervision of the Sanitary Authority. Now, no doubt there have been faults, and serious faults, in the sanitary administration of the borough, and especially as regards the dealing with outbreaks of scarlatina. And it is not the less a fact that there has been a disposition shown to withhold from the Medical Officer of Health information such as the medical men in the town could have furnished as to the occurrence of cases of infectious disease within the borough. But even where the occurrence of cases has been known, and even where deaths from the disease have been reported, but little action has been taken to arrest the spread of the disease. Thus— 1. There is an infectious disease hospital provided for the use of the inhabitants of the borough, but it has not been put to the use that it might have been or that it ought to have been put to. During the whole three months of December, January and February, only 20 cases of scarlatina were admitted into the isolation hospital, of which eight were domestic servants from invaded houses, one a dentist, one a scripture reader, and two scholars from outside the borough; and, so far as I could learn, no serious endeavours were made to induce people to use the hospital for the isolation of such cases as could not be properly isolated at home. 2. Disinfection of infected houses and things has been greatly and habitually neglected. Out of the vast number of infected houses in the borough during the late epidemic, only 30 (and those houses of well-to-do families who have asked for disinfection to be performed) have been subjected, so far as the Medical Officer of Health knows, to any process of disinfection. In these instances the process was performed or superintended by a sub-inspector of nuisances, with whose opinion as to the efficiency of the process the Medical Officer of Health and all concerned appear to have been satisfied. In other instances of disease or death, it has been considered sufficient to give some kind of "disinfecting powder" to applicants for

it. The Medical Officer of Health, even when he has known cases of disease or death, has never certified to his Authority under section 120 of the Public Health Act, and hence the Authority have not had given them the opportunity of serving necessary notices for the disinfection of infected houses and things: nor have the Sanitary Authority made any public provision under section 122 for the disinfection of infected things. 3. No care or attention has ever been given under section 125 to prevent the improper disposal of infected articles of clothing, &c., even where the person who had used them was known to have died, and notwithstanding that it is notorious that such things are often either stowed away in drawers, &c., for future use by some other member of a family, or given away or sold; and that in either case the disease is likely to be freshly lit up in a population or to be extended by these means. 4. No attention has ever been directed to infected houses or rooms under section 128 with a view to preventing their being re-let before they have been efficiently disinfected. With all this inattention and neglect it can be no matter for surprise that from time to time scarlatina springs up and spreads epidemically in the borough.

Looking at the above facts, and taking into consideration also the usual modes by which scarlatina is spread by personal communication, by infected things and infected food, it is not easy to comprehend the reason why bad conditions of drainage should have been particularly insisted on as the cause of the frequent spread of scarlatina in Halifax. It is no doubt quite true that accumulations of infected filth are sometimes agents for the extension of the disease, and it is not improbable that it may be spread by means of sewer air: but,—First, I learn from the borough surveyor that of late years a great deal of improvement has been effected in the borough with reference to these matters. The ash-pit privies formerly in common and habitual use have been largely abolished, pails for separate houses, emptied systematically by the Authority, or else waterclosets having been substituted; 5,100 houses are now provided with pails and 3,300 with waterclosets. The sewers in the newer parts of the town (built since 1873) have been provided with ventilators at distances of about 100 yards apart, although the sewer ventilation in the older parts is still insufficient; the gradients of the sewers are mostly good, and the flatter sewers are periodically flushed; all houses within the distance prescribed by statute are now drained into the sewers, and since 1873 all house connexions with the sewers have been inspected before being covered in. Since 1872 also no combined drainage under dwellings has been permitted. So that it is clear that of late years a great deal has been done by the Authority to abolish these sources of danger. Waterclosets are not, indeed, habitually ventilated as they should be, and there are other modes, such as sink pipes not disconnected, by which sewer or drain air may gain access to the interior of houses. Secondly, it is precisely in those parts of the town which are the oldest and in which the sewers are constructed on the least approved principles, where they are least perfectly ventilated, and where the house drains and connexions may be believed to be least satisfactory, namely, in East, Central, and Market wards, that during the last few years scarlatina has numbered the fewest victims. There are very few ash-pit privies left in South and West wards where the late epidemic has been chiefly prevalent. I find therefore no indications of the epidemic spread of scarlatina in Halifax being attributable to faults of sewers and drains.

The Medical Officer of Health wrote perhaps too emphatically when he stated that the distribution of milk by a certain milk carrier "was,

"beyond all question, the cause of the outbreak." He would have been correct if he had stated that this circumstance was an important element in the localization and spread of an epidemic which had previously commenced, and which was spreading, even in South ward, before the milk carrier's family appears to have been invaded. The facts stated in his special report were sufficient to establish such a *primâ facie* case as warranted the action taken to suppress the distribution of milk by the particular carrier. They did not, indeed, completely demonstrate the connexion of the outburst with the milk supply, but the Medical Officer of Health would have been to blame had he waited for absolute demonstration before advising such action.

The history of the milk supply in question is this:—

A farmer whom we may designate as A. kept six cows in the country, two or three miles out of Halifax, and morning and evening supplied milk to private families, selling it to them in small retail quantities; he also supplied two gallons every evening to the canteen of the barracks, where it was sold in small quantities to the soldiers residing there. His own cows not supplying milk enough for his trade he purchased milk from three other adjoining farms. The cows at A.'s farm were milked by A., by A.'s son who resided with him, and since October last by a man whom we will call B. In the mornings, A.'s son habitually delivered the milk to A.'s customers, calling first at the other farms to take up there more milk, which was always at once mixed with A.'s milk. In the evenings, A.'s son and B. both delivered milk. On December 25, B. delivered both the morning and evening milk, and again from January 1 to January 5, A.'s son being at that time at home ill with sore throat, which the medical practitioner in attendance believes not to have been of specific character. B., a very uncleanly person, resided in a cottage situated a short distance from A.'s farm. His family consisted of his wife and six children; the eldest of the children, a girl who had had scarlatina some years ago in Leeds, was a half-timer at a mill in Luddenden. On December 31 one of the children aged three years was taken ill with scarlatina, another aged eight years was similarly attacked on January 1 or 2, another aged six years on January 4, another child on January 5, and a fifth child aged one year on January 14. There was but one bedroom in the cottage, and in this room all the family, with B. and his wife, slept at night. During my inquiry I visited this cottage. I found it very dirty, and the bedroom so offensive that I was glad to get out of it as speedily as possible. The children had all recovered, but nothing whatever had been done to cleanse or disinfect the house and its contents, and no notice to that effect had been served by the Urban Sanitary Authority of Warley, in which district the cottage is situated. There was but one blanket for the use of the whole family, the other coverings used at night being a bundle of filthy rags, which I saw upon the floor of the bedroom, and the dirty clothing. It cannot be doubted that during the night, while the children were ill, there was a general indiscriminate use of these things by the family. Yet from such a bedroom and infected house B. went, on December 31 and on subsequent days, to milk A.'s cows, and to carry out milk and distribute it to A.'s customers. Holding in memory the lessons furnished by former experience of the readiness with which milk receives and conveys the contagium of scarlatina, it would have indeed been marvellous if the customers to whom B. delivered milk in his rounds, dipping it in small retail quantities out of the can, had escaped infection. This was the *primâ facie* case so far as B. was concerned. I have now to show that the customers did not escape.

A., on my application, furnished me with a list of the families that he was supplying with milk at the beginning of this year. He kept no books, his trade being for ready money, so that the list was made out from memory with the assistance of his son. Subsequent inquiry made from house to house, however, showed that there were but few, and those scarcely avoidable errors in the list.

Two uses were made of this list.

1. Every house, with the exception of 10 (either situated out of the borough or not determinable), was visited, and inquiry was made, where the facts were not previously known, as to the occurrence of scarlatina or sore throat in the family.

The following was the result of the investigation :—

- Total households supplied by A. 135
  - Households invaded 53
    - Households without children 29
    - All the children had had scarlatina on former occasions. 15
    - Most of the children had had scarlatina previously 7
    - None of the children had had scarlatina previously 14
      - Households believed to be insusceptible, three generations at least being said to have escaped scarlatina. 2 (of one family)
      - Milk always boiled before use 2
      - Milk given up at beginning of year on account of filthy condition of carrier 1
    - Children in households not ascertained. 7
  - Households escaped invasion 72
  - Facts as to invasion not ascertained. 10

Of the above 53 household invasions—

1	occurred	in November (sore throat).
15*	„	between December 15 and December 30 (9 scarlatina and 6 sore throats).
5	„	on December 31 (4 scarlatina and 1 sore throat).
6	„	„ January 1 (3 scarlatina and 3 sore throat).
3	„	„ 2 (all scarlatina).
7	„	„ 3 (6 scarlatina and 1 sore throat).
2	„	„ 5 (both sore throats).
1	„	„ 6 (scarlatina).
8	„	„ 7 (6 scarlatina and 2 sore throat).
2	„	„ 8 (1 scarlatina and 1 sore throat).
1	„	„ 15 (scarlatina).
2	doubtful dates	(1 scarlatina and 1 sore throat).

Total 53 viz.: 35 scarlatina and 18 sore throat.

* Of these 15 families, 5 were invaded on 29 and 30 December.

Among the 35 households in which the regular scarlatina eruption was recognised in one or more members of the family, sore throats occurred in other members of the family in 9 instances.

Of the 72 households known not to have been invaded up to February 18 (when the house to house inquiry was instituted), a considerable number, viz., 51, or 70 per cent., were more or less unlikely to suffer an invasion, either because there were no children, or because the family had been invaded on former occasions; and of 14 other families the children in them were more or less protected in at least three instances.

It is clear, at any rate, that of those households which were on the milkman's list of customers, an overwhelming proportion of those unquestionably susceptible of invasion were invaded by the disease in one form or the other; all but one out of 51 households, whose date of invasion was known, manifesting the disease on or after December 15, and all but 11 out of the 51 on or after December 29. The large majority of the household invasions, 39 out of 51, occurred during the 11 days between December 29 and January 8 inclusive, *i.e.*, from about two days before scarlatina was recognised as scarlatina in B.'s family, to the third day after, January 5, which day was the last day on which B. was permitted to milk A.'s cows, or to carry out milk to A.'s customers. After January 8 only one household is known to have been invaded among A.'s customers, and that invasion occurred on January 15.

2. Thirteen streets in the borough were selected, in which streets it was known that some families were supplied with milk by A., while others were supplied by other milk-sellers; every house was visited, and inquiry as to scarlatinal illness having occurred in them was made. In these 13 streets there were 270 families altogether, of which 82 were customers of A., and 188 customers of other milk-sellers. Of the 82 families supplied by A., 45 were found to have been invaded, while of the 188 supplied by other milkmen, only 14 were found to have been invaded up to the time of the inquiry being made. The dates of invasion of these two classes of families are important. Of the 45 families supplied by A. in these streets, all had been invaded prior to January 9 (39 of them between December 29 and January 8), whereas of the 14 families supplied by other milkmen, only three had been invaded prior to January 9 (viz., on January 1, 7, and 8), the 11 other families having been invaded between January 9 and January 30. In each of four of the 13 streets A. had only one customer, while the customers of other milkmen numbered 64; each of the four families supplied by A. was invaded, one in Christmas week, and three on January 6, 7, and 8 respectively; while of the 64 other families only two were invaded, and these invasions were as late as January 24 and 30. In this branch of the inquiry $\frac{4}{5}$ of the family invasions of A.'s customers were accounted for, so that it did not appear necessary to spend time in prosecuting it beyond the 13 streets.

It appears then to be clear from these two branches of inquiry that the spread of scarlatinal disease in Halifax was, during the last days of December and the first week of January, partly dependent upon the distribution of milk by B. to A.'s customers, and that the epidemic had been distinctly promoted by this means. The milker and carrier B. had, in December 31, fully developed scarlatina in his family, and his household arrangements were such as could not fail to attach contagious material to his person and clothing; a large proportion of the families

to which he distributed milk were invaded by the disease at and immediately after this time, up to three days subsequent to his ceasing to act as the milk-carrier. With one exception, no family among A.'s customers was attacked after the third day from such cessation, that is to say, after a reasonable period from his last distribution of milk had been allowed for the incubation of the disease. Lastly, in streets supplied by A. and also by other milkmen, the families of A.'s customers had been attacked in vastly larger proportions than those who obtained their milk from other milkmen, and also at an earlier date. Looking further at the fact that A.'s customers were most numerous in South and West wards, the inference is scarcely avoidable that the particular milk supply furnished by A. operated to an important degree to produce the special incidence and spread of the disease in these wards. Each house of the 53 infected through the agency of the milk became a fresh focus of contagion. Some of the cases on A.'s list of customers (even of the family invasions between December 29 and January 8) may indeed, like other cases not on his list, have acquired the disease through other channels than the milk supply. The fact that a number of families supplied by this milkman escaped attack has been partly accounted for, and the amount of infective matter in the several portions of milk distributed must be believed to have varied to a degree quite sufficient to account for other escapes.

At what precise date B. became personally an agent for the conveyance of the contagious principle is not determinable. It may well have been a day or two before the full development on December 31 of the disease in his child; and there is a further probability of his having himself become infective from the same source (whatever it was) as that from which the child derived the disease. The man B., or his eldest daughter who worked at a mill at Luddenden, in which village there were cases of scarlatina in November, may have introduced it into his household prior to December 31; and scarlatina had been for a long time existent in and about Halifax prior to the particular epidemic extension under consideration. It is impossible, however, to affirm that the family invasions which occurred among A.'s customers prior to December 29 were due to their milk supply.

But after making every possible admission as to the influence of the milk supply distributed by B., the large majority of the household invasions that occurred during this epidemic must be attributed to the customary methods of communication of this highly infectious disease. That such ordinary modes of spread were operative has been demonstrated to me by numerous individual instances in which persons first attacked in a family had been shortly before in direct or mediate communication with others ill with the disease. In such a case as this, it would be impracticable to trace out all the channels, some of them tortuous and obscure, by which the contagion may have travelled from the sick to the healthy; nor, with our knowledge of the fact that such channels are very numerous as well as obscure, is it necessary to do so. They are known to exist in abundance, although they may not be always easy of identification.

It is matter for regret that the occurrence of five deaths in December was not made the occasion for an attempt at discovering the extent of prevalence of the disease; the circumstance was not regarded as having anything special in it to command attention. And even on the rapid development of the epidemic in the first week of the new year, the statutory means of arresting the epidemic were but very imperfectly em-

ployed. The distribution of milk by the infected carrier was indeed properly arrested, advice as to the closure of schools (already closed for the holidays) and of public libraries, and as to the postponement of parties, &c. was given and generally adopted, excrement pails were more frequently removed from infected localities, and sewers were flushed; but there the action of the Sanitary Authority stopped. The measures specially calculated to arrest the spread of scarlatina, namely, isolation of the sick, and disinfection of infected houses, rooms, and things, were badly atall ad op ted bythem.

* * * * *

May 1881.

App. A. No. 11.

On a Prevalence of Scarlatina in Durham Registration District; by Mr. J. Spear.

No. 11.

EXTRACTS from a REPORT on the PREVALENCE of SCARLATINA in the DURHAM REGISTRATION DISTRICT; by MR. JOHN SPEAR.

THE district in question is situated in the centre of the county of Durham, covering the large area of 44,360 statute acres. It comprises within its boundaries three sanitary districts—the city of Durham, and two districts under the jurisdiction respectively of the Durham Rural Sanitary Authority and the Brandon and Byshottles Local Board. The first named—the city of Durham—possesses, on a somewhat limited area of 880 acres, a population of 17,161; the latter have together a population of 46,850; 10,850 in the Brandon and Byshottles Urban District, and the remainder in the rural district; and this population is almost entirely aggregated in some 42 scattered mining villages, the number of whose inhabitants ranges from 5,000 to between 100 or 200.

Of these districts Mr. Spear says:—

THE PREVALENCE OF SCARLATINA.

The recent high mortality from Scarlatina is not an exceptional occurrence, nor has it been due to any special or exceptional cause. Statistics, and the testimony of medical practitioners, prove that the disease is constantly present in one or other of the colliery villages, and that at frequently recurring periods there is an epidemic outburst. This is not, moreover, peculiar to the Durham registration district, but is a condition that obtains in all, or nearly all, the mining districts in the county of Durham. It constitutes a study therefore that should carry one beyond the immediate subject of this report. I will, however, record the main facts of this latest outbreak.

During 1877, scarlatina had been very prevalent in the registration district, and had caused 81 deaths. In 1878 its prevalence diminished, yet still 65 deaths, equal to a rate of 1·1 per 1,000 of the population, were recorded. Fatal cases during this year had occurred in two different districts or townships of the Union, and the Brandon district, with a mortality of 31, had suffered severely. In 1879 the number of fatal cases increased to 101. In the city there were seven deaths, in the Brandon U.S.D., 22; and fatal attacks were recorded in 12 of the 21 townships of the rural sanitary district; and of these Willington and Tudhoe, the one with a mortality of 42, and the other of 13, suffered the most severely. During 1880 no less than 188 deaths from scarlatina were registered. The disease had now become epidemic; the number of fatal cases in the city rose to 47; in the Brandon district to 29; and there were only four sparsely populated townships of the rural district in which fatal cases were not recorded; Sherburne, with 28 deaths amongst a population of about 2,500, being specially noticeable for the high fatality of the disease. The scarlatinal death-rate of the district during these two years (1879, 1880) was equal respectively to 1·7 and 3·0 per 1,000 of the population; and the progress of the epidemic in the three sanitary districts of the union, and in the several months of the two years, may be traced by the fatal cases recorded as follows:

Deaths from Scarlatina.

District.		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Durham (city) U.S.D. - -	1879	-	-	-	-	-	-	-	-	1	1	3	1
	1880	3	5	11	3	4	10	7	3	2	-	-	-
Brandon and Byshottles, U.S.D. -	1879	10	8	4	-	-	-	-	-	-	-	-	-
	1880	2	-	1	-	2	-	8	5	7	1	1	2
Durham Rural S.D. - -	1879	1	5	5	10	12	15	5	4	6	5	2	5
	1880	2	2	11	11	18	18	14	10	3	5	12	9

The Medical Officer of Health of the rural district reported from time to time that the disease was being conveyed from house to house and from village to village by unrestrained personal intercourse, and this it seems was so. There was considerable evidence that day schools were in a measure accountable for this diffusion of the disease; and although the aid of the managers was asked to prevent the attendance at school of children from infected houses, yet the means taken to comply with this request were not always sufficient. The visiting of neighbours at infected houses was freely indulged in; and I found several instances where fever cases had been treated in rooms communicating with small shops, which still remained places of public resort. In short, although, judging from the ascertained *fatality* of the disease in different localities and in the practices of different medical men, there must have been over 3,000 cases of scarlet fever during these two years in the Durham registration district, and although very many of these cases were in poor and crowded houses where proper accommodation for fever patients was not to be obtained, yet nothing was done that is worthy of record, by any of the Authorities concerned, towards limiting the spread of the disease.

The circumstances of the epidemic, the previous existence of numerous sporadic cases, and then opportunities for the spread of the disease through every known channel, were not such as to offer favourable occasions for the more exact study of its rise and progress; yet in the course of the investigation certain minor points in the etiology of the disease came under notice, and these are perhaps deserving of mention.

Out of a very large total of cases, the circumstances of 451 attacks occurring in 176 different families, most of them during the year 1880, were carefully investigated. The disease was almost entirely amongst children; the following Table expresses this feature of the epidemic:—

—	All ages.	Under 1 year.	Between 1 and 15 years.	Over 15 years.
Past attacks investigated during present inquiry (1880).	451	4	422	25

Or taking the fatal attacks, 1879–80, a like result appears:—

—	All ages.	Under 1 year.	1 to 5.	5 to 10.	10 to 15.	15 to 25.	25 and upwards.
Fatal attacks in 1879-80 -	295	5	161	102	15	10	2

The comparative immunity of infants under one year of age, which these figures show, is noticeable. I find that in the 176 infected families there were 31 infants under one year of age who were exposed as much as the older children to risks of infection, but while it was exceptional for the latter, if unprotected by a previous attack, to escape, of these 31 infants only four were known to be affected; three others it must be said died at the time of "convulsions," but even if these deaths were due to the infection of scarlatina, yet comparative immunity from attack in the case of infants, at least from attack sufficiently developed to be recognisable, would still be markedly shown. The women of the Durham colliery villages, who certainly have abundant opportunity of forming an opinion, say that "suckling infants rarely take the fever." The possibility above alluded to that infants exposed to infection may more often than appears be influenced by the scarlatinal poison, renders it hazardous to draw conclusions from apparent insusceptibility exhibited in after life. Yet the evidence seems to point to adults as really possessing a certain immunity, apart from that accorded by previous infection. Thus amongst 42 persons above the age of 18, who were very positive of not having suffered previously from the disease, and who were living in infected rooms, there were only seven distinct attacks; 11, however, suffered from slight sore throat and malaise during some period of their exposure, a fact again suggestive of relative immunity in their case, for rudimentary or abortive attacks in children are far less common. Several of these partially developed cases, however, occurred after much exposure to infection in persons who had previously suffered from the disease; and in two instances rudimentary attacks appeared to start fresh family outbreaks; thus affording additional reason for assuming their origin in, and capability of transmission of, the specific contagion.

In all but 46 of the 176 infected families the attacks were multiple; and in almost all cases there was a distinct interval between the first and second attacks in a family, a circumstance itself going to show that the disease was spreading mainly by personal intercourse, and not by any common influence of food supply or the like. The interval in 52 cases, in which reliable information on this head was obtained, was as follows: Two or more attacks occurred simultaneously in one family in only three cases, in four, the interval between the first and second was 24 hours; in five, two days; in 12, from two to seven days; in 13, from 7 to 10; in 10, from 10 days to a fortnight; and in six a longer period.

The *type* of the epidemic, judged of by the rate of mortality alone, was not a severe one, for the proportion of fatal attacks was about 9 per cent. of the whole; but the moderateness of the mortality seems rather to have been due to the comparative absence of fatal sequelæ, for in respect of the original infective process, the facts would rather suggest exceptional severity. Thus, the duration of the illness is recorded in 207 of the 295 fatal cases; in 57 of these the fatal termination occurred on or before the third day, in 106 within a week, in 45 in from one to two weeks, in 26 in from two to three weeks, and in 30 cases after a longer time. Again, in 75 of the 295 cases (these all rapidly fatal) the deaths are recorded as from *malignant* scarlatina, or from scarlatina with one or other of the cerebral symptoms that indicate at this early stage deep infection; in 49 cases the disease is spoken of as "scarlatina anginosa," and in eight cases as scarlatina with diphtheria. On the other hand in only 18 of the 295 cases is *dropsy* mentioned as contributing to the fatal result.

It is to be doubted, however, in spite of certain authoritative opinion to the contrary, whether the type of an epidemic, as a whole, of scarlatina can often be properly spoken of. In this, as in most outbreaks, "malignant" cases, and cases of extreme mildness, were seen side by side; the one apparently giving rise to the other. Certain localities, it is true, suffered to an exceptional extent; and it is very probable that the virulence of the disease in such cases was in a measure determined by local sanitary conditions. In a district, however, where such conditions are, as a rule, generally unsatisfactory, it is too hazardous to draw comparisons for the purpose of speaking definitely on this point. I will only say that the disease was exceptionally prevalent and fatal, as also, shortly before, was

measles, at High Sherburne in the R.S.D., where, amongst other grave sanitary defects, there is no proper water supply conveniently accessible; at Littletown, in the Brandon U.S.D., where similar conditions at the time of the outbreak largely prevailed; and also in certain filthy and crowded courts, as well as in some damp houses of modern construction, in the city of Durham. Tudhoe and Willington also, the largest and most populous villages in the R.S.D., both badly drained and badly administered, suffered from the excessive prevalence of both diseases (measles and scarlatina). Apropos of the prevalence of measles, it may be mentioned that in the course of the inquiry suspicion arose that the prevalence of scarlatina might be in some way related to the pre-existing prevalence in the locality of measles; and it seemed as if those who had recently passed through an attack of the latter disease exhibited a higher susceptibility than others not so circumstanced to the contagion of scarlatina. The observation is not altogether new, for a somewhat similar one is recorded by Kostlin and Lōschner in the course of their epidemiological studies at Stuttgart; our information on the point is however as yet too meagre to render a more than passing notice of it here permissible.

I have had to refer to the general excessive prevalence of scarlatina in this county of Durham, and since the subject is one deserving of careful consideration by the Sanitary Authorities and Medical Officers of Health, I may be permitted to make more specific allusion to it. For the last thirty years Durham has, in each quinquennial period, shown a scarlatinal mortality-rate higher than that of any other county in the kingdom; and whilst the average rate for England and Wales is 0·87, that for Durham during the last thirty years is 1·4; and the rate is not diminishing. Almost all the registration districts share in this excess, at least there are only three exceptions. Darlington has an average rate for the period named of 0·81 per 1,000; Teesdale an average rate of 0·73, and Weardale one of 0·85; in all the others the mortality is sustained at an excessive rate, varying from 1·33 at Houghton-le-Spring to 1·62 at Bishop Auckland.

To some small extent, no doubt, this excess may be explained away by a larger proportion of children living in Durham as compared with the average English county; and to a further extent it may be accounted for by a variety of unwholesome conditions, notably of lodgment, that mining villages too often exhibit in fullest intensity; and significance may be granted to these two considerations as affording some reason why scarlatina is exceptionally fatal in Durham, beyond the rate of fatality customary to the disease in other communities. But the fact of excessive prevalence and mortality is not in any wise to be ignored or made light of because it may in a measure be explained. It is certain that the ravages of the disease might, by enlightened measures of precaution, be confined within much narrower limits, perhaps indeed altogether controlled; and it becomes the sanitary authorities to exercise to the utmost their powers in this behalf.

The establishment of hospitals, and the careful and systematic enforcement of the various provisions of the Public Health Act in regard to the spread of infection, are, I conceive, the first and most essential of the precautionary measures needed.

October 1881.

App. A. No. 12.

On an Outbreak of Enteric Fever at Blackburn; by Dr. Airy.

No. 12.

On an Outbreak of Enteric Fever at Blackburn in Lancashire; by Dr. Hubert Airy.

From a report of the Medical Officer of Health for the borough of Blackburn, dated April 1881, it appeared that typhoid or enteric fever had been unusually prevalent in the borough since the early part of March, as many as 182 cases having been reported to the Sanitary Authority in the six weeks from March 6 to April 16, and 24 deaths having been registered in the same period from that disease.

The Board thereupon ordered inquiry to be made by one of their Medical Inspectors into the circumstances of the outbreak. The inquiry was made during the month of June 1881.

A brief description of the district is necessary to make intelligible the account to be given of the epidemic.

Description of the district.

Blackburn, one of the most important seats of the cotton manufacture, in the north-eastern division of Lancashire, lies in a valley which receives a small stream, the Blakewater, from the north-east. About a mile to the south-west of the town this stream falls into the river Darwen, a southern tributary of the Ribble. To the north-west of the town the ground rises steeply to a ridge called Revidge, parallel to the valley, 750 feet above mean sea level. To the south-east the town is abutted on by a northern spur from a range of high ground between Haslingden and Over Darwen, reaching a height of more than 1,000 feet above the sea. Part of this range makes the gathering ground of the existing water supply of Blackburn.

Geology.

On the map of the Geological Survey it is seen that Blackburn lies at the north-western border of the Lancashire coal-field, on the Gannister beds. Two or three small collieries are worked within a mile or two of the town. The rock is a sandstone, locally known as "rag-rock," much fissured and allowing easy passage of water. It is largely quarried for building purposes. The ridge of Revidge is composed of millstone grit. On this (northerly) side of the town the strata dip towards the south; on the opposite side of the valley they are more nearly horizontal. At Belthorn, a village from 800 to 900 feet high, on the hill crest between Blackburn and Haslingden, the dip of the sandstone strata is westerly. There is a good deal of stiff clay on the lower slopes of the hills.

Population.

At the recent census (1881) the borough of Blackburn (which has been extended in 1877 and again in 1879) was found to have a population of a little over 104,000. In 1871 the population of the borough within narrower compass, was 82,926. It may be mentioned that in 1801 the inhabitants numbered 11,980, and in 1770 only 5,000. The borough now comprises the whole of the Blackburn registration sub-district, and parts of the Harwood, Darwen, and Witton sub-districts. The Sanitary Authority is the Town Council. They have appointed a separate committee for dealing with sanitary business.

Dwellings, streets, &c.

During the past 40 years Blackburn has had a code of bye-laws under which the building of new houses has been well regulated. The consequence is that in the greater part of the town, more especially in the populous outskirts, the houses are on the whole of a good character, built of red brick, two storied, with large sash windows to the bedrooms

and, with the rarest exceptions, well provided with eaves-troughing, and fall pipes to carry off the roof rain. The fall pipes lead direct into the sewers, and serve in some measure to ventilate them.

The streets (except some of the oldest) are wide, and mostly paved with ragstone setts. In several parts of the town the work of paving is actively in progress. A good deal of house property of a poor description has been purchased by the Corporation, and removed to make way for new streets, or for the widening of old ones. In the general care of streets and houses, in the public buildings, and in the admirable Corporation Park, which cannot but be regarded as a valuable aid to the health of the hard worked townspeople, there is ample evidence of public spirit in the town.

The Corporation employ in sanitary work of various kinds about 100 men and 70 horses, a large number of them being occupied in the regular scavenging of the streets and removal of night-soil and emptying of ash-bins. In the summer the watering of the streets is properly attended to. A large market is held twice a week in the middle of the town, leaving a large quantity of vegetable refuse to be removed by the scavengers.

Excrement disposal, sewerage, &c.

Of the night-soil arrangements I have to speak more particularly. For some years past there has been going on a systematic course of replacing the old midden closets by tub-closets and water-closets. At the time of my inquiry there were 1,141 water-closets and 7,932 excreta tubs; while 12,227 middens and cesspools still remain. In new houses, midden-privies are not allowed. The tubs used in the tub-closets are made by sawing paraffin tubs in two. They are accessible to the night-men from the back alleys by small square doors, and are emptied once a week in rotation by gangs of men going their appointed rounds every night.

* * * * *

The discharges from the water-closets go into the sewers, with all house drainage and most of the surface water. Provision is made for relieving the main sewers of storm-water by means of lateral channels leading into the river. The sewers are partially ventilated by street gratings and rain pipes. They can be flushed from the street hydrants on the water mains. The outfall sewer delivers at Witton, in the western outskirts of the town, into a range of narrow settling tanks where lime is added, and a considerable portion of the solid matter is deposited, stored under cover, and sold to farmers. The effluent sewage is conveyed in earthenware pipes to two sewage farms (Higher Park and Samlesbury) having a total of 684 acres, of which 530 are available for sewage irrigation.

* * * * *

Water supply.

Previous to 1845, the water supply of Blackburn was derived partly from wells and partly from a spring on the north side of the town. In that year a private company obtained an Act for the construction of waterworks, which they completed in 1848. These were afterwards enlarged to meet the wants of the fast growing population, and were finally purchased by the Corporation in 1875, with powers for still further extension. These powers, however, were abandoned in 1877 in favour of an entirely new scheme of water supply which is now being carried out, but which cannot come into public use until next year.

Meanwhile the old waterworks suffice, though sometimes barely suffice, to supply the town. They draw their resources from an extensive gathering ground to the south-east of the town on the moors

between Haslingden and Over Darwen, 4 to 5 miles distant, on the millstone grit and lower coal measures. The surface is chiefly pasture land, some of it peaty, with a little wood. Eight or ten farmsteads lie scattered upon it. Pains have been taken to protect the streamlets from pollution, and a row of cottages that formerly stood close to a watercourse has been pulled down. Still the protection is not perfect. Oozings of farmyard surface drainage still find their way into the water channels. Little of the land is purposely manured. The surface and spring waters descend by two converging streamlets, and, at the point where these meet, are received in a reservoir or "lodge" known as the Pickup Bank lodge, formed by a dam built across the valley, 720 feet above the sea. On one of the contributory streamlets there is a smaller lodge, called Daisy Green, 965 feet above the sea. There are several cottages near the Pickup reservoir, but care is taken to divert their drainage so that it does not enter the reservoir. From the Pickup lodge the water is led in a rough stone culvert 3 feet in diameter, laid in clay, and carried along the western slopes of the Belthorn hill for a distance of two miles, and delivered into a storage reservoir, 644 feet above the sea, at Guide, a little village two miles from Blackburn. This Guide reservoir has a capacity of 90,000,000 gallons. About the year 1859 a new and larger reservoir was constructed, contiguous to the Guide reservoir and filled from the same conduit, but nearer to Blackburn and at a lower level by 40 feet; this is known as the Fishmoor lodge, and has a capacity of 310,000,000 gallons. After the long drought in the summer of 1880 this reservoir contained only 50,000,000 gallons, and several acres of the bottom were exposed at the shallow upper side.*

The western and south-western parts of the town, together with a strip running up in a north-easterly direction, are supplied from Fishmoor. A separate main is carried from Guide right through the town, supplying only a few blocks of houses in the southern, central, and northern quarters, and serving to replenish a well 200 feet deep on Revidge, the hill to the north of the town, whence the water is pumped by an engine to a small covered reservoir at the top of Revidge hill, 716 feet above the sea, capable of holding 500,000 gallons. This supplies the northernmost part of the town. The eastern quarters are supplied from a source which is usually totally distinct from those above-mentioned, and is derived from a small colliery ("White Birk") about a mile out of the town to the east. This water comes principally from some disused workings, and the bulk of it is unobjectionable, but a small quantity comes from the headings where the men are now at work, and this portion must necessarily be of doubtful purity. From the colliery the water is forced in 9-inch iron pipes up to a small reservoir ("Audley") on the northern slope of the Guide hill, about ten feet below the level of Fishmoor, and containing 12,000,000 gallons. There is a communicating pipe, which can be opened or closed at will, between this Audley reservoir and the main from Guide, and in ordinary times the Audley water is frequently let into the Guide main, when it is desired to save the water in the Guide lodge; for it is the policy of the waterworks manager always to keep a good head of water in Guide for fire extinction and other emergencies as well as for the supply of the higher dwellings on the north side of the town. Conversely the Guide water can be admitted to replenish the Audley reservoir, if desired; but this is very rarely the case. (Such an occasion did arise last February, as will be mentioned below.)

* Appended to this report (page 90) is an analysis by Professor Frankland of a sample of water taken in June 1881 at the outlet of the culvert.

The water is laid on to every house, under constant pressure, at a rate of 8 per cent. per annum on the rateable value of the house. Large quantities are consumed for trade purposes at the breweries, cotton mills, and other establishments; but little remains in the summer time for watering the streets and flushing the sewers.

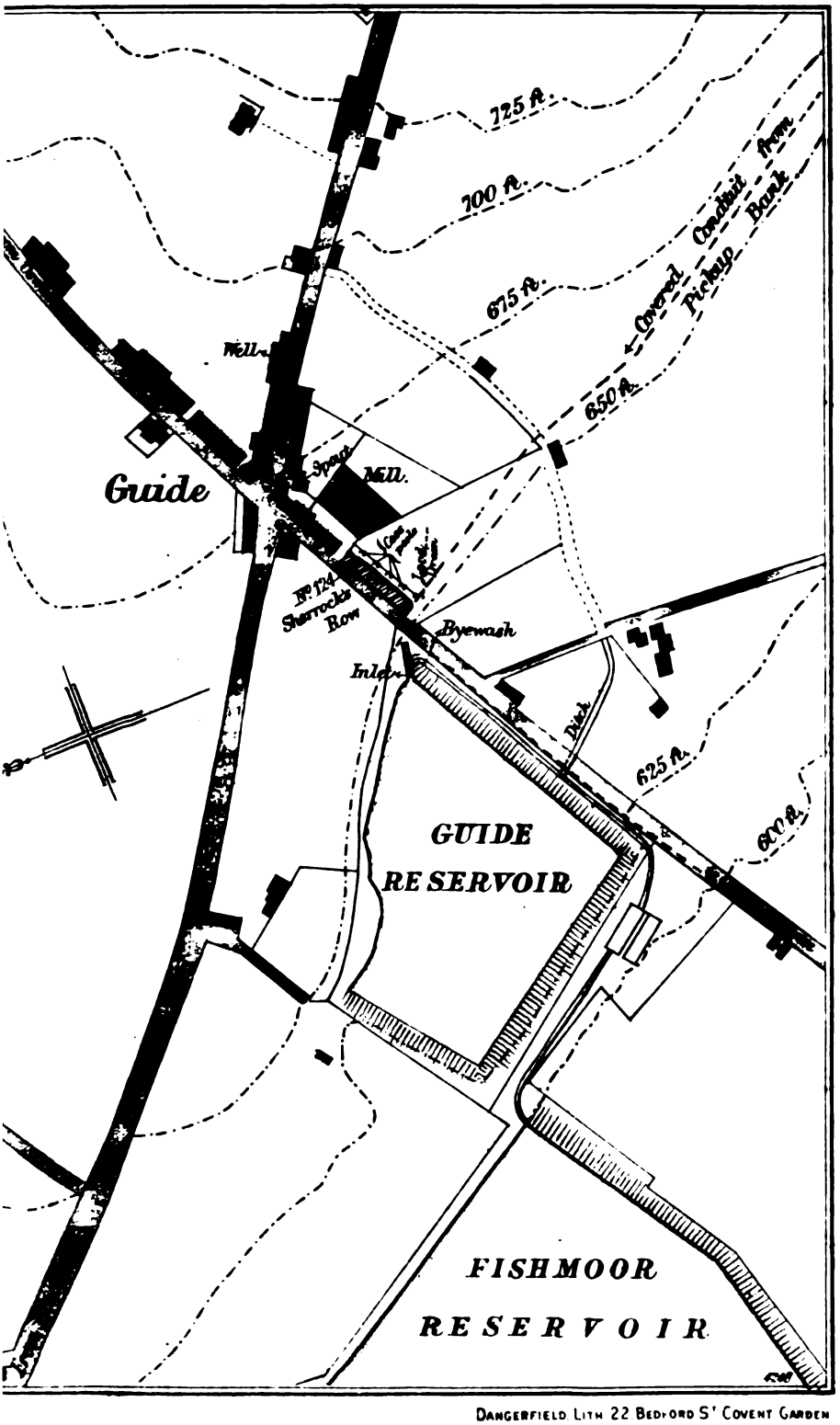
Risk of pollution of water supply.

Now it is evident that this water supply of Blackburn runs the risk of pollution at its several sources. There is risk at the gathering ground above Pickup Bank; there is risk at the White Birk Colliery of some accident similar to that which befell the Caterham well; and there is risk at the well on Revidge, for houses are pretty numerous round about, and the soil is a porous sandstone rock. Moreover, as regards the water from Pickup Bank, there is risk at very many points along the route by which it is conveyed to the town. The stone culvert above described is of rough construction, built of the ragstone of the district in rude wedge-shaped lumps, fitted together without mortar or cement, but well bedded in thick puddle: and remembering that this culvert has lain for more than 30 years, only three or four feet deep, on the slope of the hill side, with a constant tendency to increase of pressure on the upper side, and lessening of pressure on the lower side, it can hardly be supposed that the structure is still sound throughout. Indeed on one or two occasions at different points the crown of the arch has fallen in, and probably at a hundred points it has yielded more or less, so as to admit a leakage of sub-surface water on the upper side. The Corporation have been sensible of the danger involved in this condition of things, and have, some time back, taken pains to prevent the surface water from lodging on the upper side of the mound which overlies the culvert, by cutting trenches and laying drain pipes to carry it away either under or over the culvert. An inspection made last autumn (1880) by the Health Officer (Dr. Stephenson) and the Inspector of Nuisances (Mr. Prebble) revealed the presence of dangerous nuisances in the shape of town manure on the pastures immediately above the line of the culvert. Freedom of manuring was expressly reserved to the neighbouring owners, tenants, or occupiers by the Waterworks Act of 1845. The only remedy the Corporation can use is to refuse to sell manure to the farmers on these lands. They cannot prohibit the manuring of the land, and the farmers can get manure elsewhere. Danger from manuring therefore still remains. There is also the sewage and ordure of Belthorn, the village on the crest of the hill, above the line of the culvert, to be taken into account. At the time of construction of the waterworks Belthorn had no sewer nor cesspool, but disposed of its slops and excreta close around the dwellings. Of late years the house slops have been received in a roadside sewer, delivering into a watercourse which formerly was impounded in a little "*lodge*" close above the culvert, and used to supplement the supply from Pickup Bank. Even to the time of my visit the conduit remained open at this point, but the lodge had long before been emptied by a pipe carried under the culvert. Still it has occasionally happened that this pipe has been choked with rubbish or with snow, and the water has half-filled the lodge before it has been possible to clear the pipe again. The water bailiffs, however, declare that the water in the lodge under these circumstances never reached the open conduit. Again, there are one or two other points where sewage from Belthorn has to pass over or under the culvert, and where the accident of a defective joint might admit impure water to the latter. The drainage from one row of houses goes into a cesspool on the hill slope. The cesspool sometimes overflows, and the liquid runs down a lane and enters a drain which

passes under the culvert. Even in the last 20 yards of its course before it discharges into the Guide reservoir, the culvert is in manifest danger of receiving soakage from the neighbourhood of a row of cottages (Shorrock's Row) in the village of Guide. (*See* plan annexed.) The slops from these cottages are thrown out partly in front into the road gutter, which carries them over the culvert, with no security against percolation except the bed of puddle in which the culvert is wrapped, and partly into a six-inch pipe drain at the back, which, at the lower end of the row, is carried under the last house and across the road to join a larger stone drain from a higher part of the village. At and from this point the stone drain is replaced by 12-inch earthenware pipes, which have to be bent at the joints, to ride over the water-culvert. At my request the ground was opened and these drains were examined. They appeared sound, as regards any leakage from them, though at one bent joint over the crest of the culvert there was a gap of half an inch.

In order that I might examine the inside of the culvert, the Borough Engineer (Mr. W. B. Bryan) and the Waterworks Manager (Mr. Wilson) courteously arranged to shut off the water at the Pickup lodge for 18 hours. At the end of that time there was only about an inch of water running out at Guide, and it was possible to creep into the culvert with a lighted candle. The rough construction of the work was very apparent, making progress difficult. At places the crown of the arch had evidently yielded considerably, large stones jutting down into the headway. Some lay loose at the bottom, proving by the thick smooth incrustation of mud upon them that they had lain there a great length of time. At points corresponding to the two road gutters at the bottom of Shorrock's Row there was evidence of infiltration of fluid leaving a ferruginous deposit on the stones on the upper side, but there was no perceptible odour other than earthy. At several other places similar signs were observed, and at a point 27 yards from the outlet water was seen dripping in. I collected a small bottleful, which has been examined microscopically by Professor Frankland, who reports that it contains no moving organisms. On opening the ground at a corresponding point in the pasture above, the men struck upon an old stone land drain, which was then traced some distance back and appeared to run obliquely across the meadow from the upper side. Approaching the culvert it ran within nine yards of the last of a row of privy pits which lay outside the bounding wall of the back yards of Shorrock's Row, accessible from the meadow, for the convenience of the farmer who took the manure. The farmer assured me that he spread this manure only on the land below the culvert, never above; but there were signs of the overflow from the privy pits having been conducted on to the pasture above the culvert. The impression left upon my mind, though I could not positively prove the fact, was that there was a probability of soakage from these privy-pits and from the slop gutter in front of Shorrock's Row affecting the purity of the water in the culvert. I have dwelt somewhat at length on these dangerous conditions along the line of the conduit because I shall have to show that the chief outbreak of enteric fever in Blackburn followed close upon and possibly was caused by the occurrence of enteric fever at Belthorn and Shorrock's Row. The water on leaving the culvert, just within the wall of the reservoir enclosure, runs in an open channel for 20 or 30 yards before discharging into the reservoir. An empty can or two lying in this channel showed that it was exposed to casual additions; and I noticed just within the gate of the enclosure and immediately over the mouth of the culvert the remains of human ordure. In the side of the open channel is a gate-sluice which, when desired, can

PLAN OF A PART OF THE BLACKBURN WATERWORKS.



DANGERFIELD LITH 22 BEDFORD S^T COVENT GARDEN

be set open so as to divert the stream, or part of it, into an open by-channel which runs down between the Guide embankment and the public road and is finally turned into the lower (Fishmoor) reservoir. In its course it receives the contents of a ditch, which when traced back is found to take origin at the back of some dwellings in the upper part of Guide village, whence it comes along a cartway trodden and befouled by cattle, past a farmyard, and through a field, exposed in its whole length to the risk of pollution. I heard tales also of mischievous fellows throwing "nast" (filth) into the reservoirs themselves. The six foot enclosure wall is easily climbed.

New scheme of water supply.

Partly because of the prospective insufficiency of the existing supply, and partly because of the risk of pollution to which it is exposed, the Corporation, by an Act of 1877, have obtained power to carry out an entirely new scheme of water supply, at an estimated cost of 430,000*l.* They resort to a wholly new gathering ground on the Brennand and Whitendale moors in Bowland Forest on the western border of Yorkshire, 22 miles north of Blackburn, and impound separately two streams known by those names, Brennand and Whitendale, tributaries of the Hodder. These moors are bare of habitations, and the water is pure and soft. It is to be brought in 30-inch cast-iron pipes over hill and dale, twice crossing the river Hodder and once the Ribble, and between them mounting the northern slopes of Longridge Hill and supplying Stonyhurst College, passing through the eastern outskirts of the town, carried up the hill to the south, and finally delivered into the existing Fishmoor reservoir. The relative levels allow of the water being thus delivered by gravitation. This supply to the town is expected to be superabundant, the amount deliverable being 6,000,000 gallons a day, and the Corporation hope to supply some neighbouring districts also. The work is actively in progress. In the last 12 months the expenditure has averaged over 10,000*l.* a month, and latterly it has been 12,000*l.* a month. Completion is expected next summer, 1882.

* * * * *

Notification of infectious disease.

By a Local Improvement Act dated 3rd July 1879, the Corporation have obtained certain powers in relation to public health beyond what is given by the Public Health Act of 1875. Among these are powers for requiring the alteration of any privy, ashpit, tub-closet, cesspool, or other like accommodation of any house within the borough to such other system of privy, &c. as they may approve; powers for using patent rights as to dealing with sewage, excreta, &c.; power to provide temporary shelter or house accommodation for the member of a family in which infectious disease has appeared; to provide female nurses for attendance upon persons suffering from infectious disease; to order the temporary closing of schools or other places of public resort situate in neighbourhoods threatened with or affected by infectious disease, and of shops, dairies, &c., where infectious disease has appeared; and to restrain communication with infected houses; and lastly, powers for enforcing the notification to the Sanitary Authority of cases of infectious disease. For this purpose, under a penalty not exceeding 5*l.* the occupier of the house in which a case of infectious disease occurs, or, if a lodger, the patient himself or the head of his family, is required, if no medical man is in attendance, to give notice to the Health Officer or to the Inspector of Nuisances. If the patient is attended by a medical man, the duty of notification devolves upon the latter. Every practitioner in the town is supplied gratuitously with printed forms of certificate to be

used for the purpose. A fee of 2*s.* 6*d.* is paid by the Corporation for every such medical certificate, but not more than one fee in a month to the same medical practitioner for certificates given by him in respect of the same disease occurring in the same building.

* * * * *

Mortality.

The statistics of births and deaths in Blackburn are such as might be expected in a crowded and fast growing manufacturing town, in which the senile population is comparatively small, and the child-bearing population comparatively large; and where a large proportion of the young mothers are engaged all day in millwork which robs their infants of maternal care.

The returns relating to the Blackburn registration sub-district, which consists of the township of Blackburn, may be taken as fairly representing the whole borough. (At the recent census the sub-district contained 91,956 persons, and the borough 104,000.) Taking the average for the 11 years 1870–1880, it is seen that the birth-rate per 1,000 of the population has been 40·5; the death rate, 27·8; the deaths under five years, per cent. of the births, 20·5; the deaths at 60 and over, per cent. of the total deaths, 15·7. The deaths from scarlet fever have been 1·5 per 1,000; from diarrhœa, the same; from fever (principally enteric fever) 0·7 per 1,000; from whooping cough nearly as much; from measles a little more; from small-pox and diphtheria an average of two or three deaths a year each. From these seven principal zymotic diseases together the death toll has been 5·3 per 1,000 per annum.

Enteric fever.

In the deaths from "fever," with which this inquiry is more especially concerned, there has been on the whole a decrease during the 11 years 1870–1880, the last half of that period having an average of 52 per annum compared with an average of 63 per annum in the first half. Recently, however, there has been a marked rise in the fever mortality. In the fourth quarter of 1880 there were 19 deaths, and in the first and second quarters of 1881, 20 and 22 respectively. In connexion with these figures it is interesting to note the numbers of cases of enteric fever that have been reported to the Sanitary Authority by the medical men. They are given in the following Table:—

1880.

January	14	July	10
February	8	August	6
March	6	September	20
April	11	October	30
May	5	November	37
June	5	December	16

1881.

January	6	April	61
February	14	May	28
March	149	June (8 in first week.)	

Noting that the fever mortality has varied but little in the last three quarters, while the number of cases reported in the first quarter of this year was greatly in excess of the previous quarter, we may infer that the type of the disease was less severe in the more recent period.

There was a decided rise, according to this list, in the autumn of 1880, but it subsided in the winter. In March of the present year a phenominal outbreak occurred, which it will be worth while to trace more minutely. The numbers of cases reported day by day (each of which represented a new household invaded) were as follows:—

1881.

Jan.	Feb.	March	April	May	June
1 - —	1 - —	1 - 3	1 - 2	1 - —	1 - —
2 - —	2 - —	2 - —	2 - 2	2 - 1	2 - 1
3 - —	3 - —	3 - —	3 - 1	3 - —	3 - 3
4 - —	4 - —	4 - —	4 - 6	4 - 2	4 - —
5 - —	5 - 1	5 - —	5 - 2	5 - 2	5 - —
6 - —	6 - —	6 - —	6 - 4	6 - 2	6 - 3
7 - —	7 - —	7 - 4	7 - —	7 - 3	7 - 1
8 - —	8 - 2	8 - 1	8 - —	8 - 1	
9 - —	9 - 1	9 - 2	9 - 5	9 - 1	
10 - —	10 - 1	10 - 7	10 - 1	10 - 1	
11 - —	11 - 3	11 - 3	11 - 6	11 - —	
12 - —	12 - —	12 - 11	12 - 2	12 - —	
13 - —	13 - 1	13 - 2	13 - 4	13 - 1	
14 - —	14 - —	14 - —	14 - —	14 - —	
15 - —	15 - 1	15 - 3	15 - —	15 - —	
16 - —	16 - 1	16 - 16	16 - 4	16 - —	
17 - —	17 - —	17 - 11	17 - —	17 - 4	
18 - —	18 - —	18 - 7	18 - 1	18 - —	
19 - 1	19 - —	19 - 12	19 - 4	19 - —	
20 - —	20 - —	20 - 7	20 - 2	20 - 1	
21 - —	21 - —	21 - 11	21 - 1	21 - —	
22 - —	22 - 1	22 - 11	22 - —	22 - —	
23 - —	23 - 2	23 - 8	23 - —	23 - 2	
24 - 1	24 - —	24 - 5	24 - —	24 - —	
25 - —	25 - —	25 - 5	25 - 6	25 - 2	
26 - 2	26 - —	26 - 3	26 - 3	26 - 1	
27 - 1	27 - —	27 - —	27 - 4	27 - 1	
28 - —	28 - —	28 - 3	28 - 1	28 - 3	
29 - —		29 - 4	29 - —	29 - —	
30 - —		30 - 4	30 - —	30 - —	
31 - 1		31 - 6		31 - —	

These dates must not be mistaken for the dates of *attacks*, but are the dates on which the certificates were signed, that is to say, when the medical attendant was sure of the nature of the disease. The real dates of attack would in general be some days earlier. We must not attempt, therefore, to deal with them very minutely. It is, however, sufficiently evident that the great outbreak began in the first week of March, and speedily reached such a height that new cases were reported at the rate of 10 or 11 a day; and it appears also that the cause, whatever it was, must have persisted, or else new causes must have come into operation, with gradually diminishing effect, for at least two months.

In examining into the origin of the outbreak it is important to inquire in what localities the first cases arose. For this purpose it is convenient to divide the town into districts—central, northern, north-eastern, eastern, south-eastern, southern, south-western, and western. In the following table the cases reported since the beginning of 1880 are distributed month by month according to the districts in which they occurred:

APP. A. No. 12.

On an Outbreak of Enteric Fever at Blackburn; by Dr. Airy.

Wards - -	St. Mary's.	St. John's.	Trinity.		Park.		St. Peter's and St. Mark's.	St. Paul's
Estimated Population - -	5,160.	15,600	19,000		23,700.		23,400	16,900.
	Central.	North.	North-East.	East.	South-East.	South.	South-West.	West.
1880.								
January - -	—	—	6	1	2	—	2	3
February -	—	—	2	—	—	1	4	1
March - -	—	1	1	1	1	—	1	1
April - -	—	2	5	1	—	1	1	1
May - -	—	1	3	—	—	—	1	—
June - -	—	—	1	—	—	1	1	2
July - -	—	1	2	—	2	—	5	—
August - -	—	—	2	—	—	1	1	2
September -	—	1	—	2	3	1	12	1
October - -	—	4	2	3	7	2	7	5
November -	1	10	4	3	4	1	8	6
December -	—	1	2	—	1	2	6	4
Total -	1	21	30	11	20	10	49	26
Rate per 1,000	0·2	1·3	2·1		1·2		2·1	1·5
1881.								
January - -	—	1	2	—	—	—	2	1
February -	—	1	3	—	2	2	5	1
March - -	**2**	**13**	**21**	**8**	**7**	**25**	**44**	**29**
April - -	—	6	7	1	9	10	12	16
May - -	1	3	3	3	2	3	10	3
Total -	3	24	36	12	20	40	73	50
Rate per 1,000	0·6	1·5	2·5		2·3		3·1	3·0

The local distribution, day by day, during February and March was as follows:—

	Central.	North.	North-East.	East	South-East.	South.	South-West.	West.
1881.								
February 1 -	—	—	—	—	—	—	—	—
„ 2 -	—	—	—	—	—	—	—	—
„ 3 -	—	—	—	—	—	—	—	—
„ 4 -	—	—	—	—	—	—	—	—
„ 5 -	—	—	1	—	—	—	—	—
„ 6 -	—	—	—	—	—	—	—	—
„ 7 -	—	—	—	—	—	—	—	—
„ 8 -	—	—	—	—	2	—	—	—
„ 9 -	—	—	—	—	—	—	1	—
„ 10 -	—	—	—	—	—	—	1	—
„ 11 -	—	1	—	—	—	—	2	—
„ 12 -	—	—	—	—	—	—	—	—
„ 13 -	—	—	1	—	—	—	—	—
„ 14 -	—	—	—	—	—	—	—	—
„ 15 -	—	—	1	—	—	—	—	—
„ 16 -	—	—	—	—	—	1	—	—
„ 17 -	—	—	—	—	—	—	—	—
„ 18 -	—	—	—	—	—	—	—	—
„ 19 -	—	—	—	—	—	—	—	—

	Central.	North.	North-East.	East.	South-East.	South.	South-West.	West.
1881.								
February 20	—	—	—	—	—	—	—	—
„ 21	—	—	—	—	—	—	—	—
„ 22	—	—	—	—	—	1 at Guide	—	—
„ 23	—	—	—	—	—	—	1	1
„ 24	—	—	—	—	—	—	—	—
„ 25	—	—	—	—	—	—	—	—
„ 26	—	—	—	—	—	—	—	—
„ 27	—	—	—	—	—	—	—	—
„ 28	—	—	—	—	—	—	—	—
March 1	—	—	1	—	—	—	—	2
„ 2	—	—	—	—	—	—	—	—
„ 3	—	—	—	—	—	—	—	—
„ 4	—	—	—	—	—	—	—	—
„ 5	—	—	—	—	—	—	—	—
„ 6	—	—	—	—	—	—	—	—
„ 7	—	—	1	—	—	2	1	—
„ 8	—	—	—	—	—	—	—	1
„ 9	—	—	1	—	—	—	—	1
„ 10	—	1	1	2	—	1	2	—
„ 11	—	—	2	—	—	1	—	—
„ 12	—	—	2	1	1	3	3	1
„ 13	—	—	2	—	—	—	—	—
„ 14	—	—	—	—	—	—	—	—
„ 15	—	—	—	—	—	1	2	—
„ 16	—	1	—	1	—	6	6	2
„ 17	—	—	4	2	1	—	2	2
„ 18	—	2	—	—	1	2	2	—
„ 19	—	3	2	—	1	—	1	5
„ 20	—	—	1	—	—	—	—	6
„ 21	—	—	2	—	—	1	7	1
„ 22	—	3	1	—	1	2	1	3
„ 23	—	1	—	2	1	2	2	—
„ 24	—	—	—	—	—	2	2	1
„ 25	—	—	1	—	1	1	1	1
„ 26	—	—	—	—	—	—	2	1
„ 27	—	—	—	—	—	—	—	—
„ 28	—	—	—	—	—	—	2	1
„ 29	—	1	—	—	—	—	2	1
„ 30	1	—	—	—	—	1	2	—
„ 31	1	1	—	—	—	—	4	—

It is here seen that on the 7th of March cases of fever were reported from the north-east, south and south-west quarters of the town, next day, one from the west; on the 9th, from the west and north-east; on the 10th, from the north, north-east, east, south, and south-west. Evidently the outbreak was pretty general from the very first. The central district, however, appears to have remained untouched till the end of March, and in the south-east quarter the outbreak was a little later than in the others. The population of the south-east quarter, belonging principally to the artizan class, is comparatively small and well-housed with wide airy streets, at an elevation of 50 to 160 feet above that of the greater part of the town. The central district, at a comparatively low level, has also a small population, chiefly of tradesmen. This district appears to be singularly free from fever. Throughout the year 1880, only one case was reported from this part of the town.

If we compare the distribution of the recent acute epidemic with the distribution of the more chronic prevalence of fever in 1880, we see that they do not very greatly differ, though there is a reversal of relative incidence between the south-eastern and southern districts, and increased incidence on the south-western and western. It seems, therefore, not improbable that the cause of the recent outbreak may have been a repetition in an intensified form, of the circumstances, whatever they may be, to which the habitual presence of fever in the town is due, with something special to account for the greater prevalence in the south, south-west, and west.

The general opinion of the medical profession in the town is that the fever was caused by impurity of the water. The artizans, returning to their homes from the dusty mills where they have been working half the day, go straight to the water tap and take a deep draught. There is general complaint of the quality of the water. The branch mains and service pipes contain a good deal of sediment, and the water as drawn from the taps is often turbid and unpalatable.

There is no reason to think that milk has been concerned in the spread of the fever. The milk-walks are numerous, and the dairies lie far apart on different sides of the town. It cannot be supposed that many of them became infected simultaneously. Very little milk is drunk by the artizans and their families; and in many instances where fever broke out it could be positively asserted that no milk had been drunk.

The drainage, as far as I could see, was not to blame. The fever was not generally found in relation with local defects of trapping and the like; nor was there evidence of much nuisance in the shape of offensive effluvia from the street gratings. One street in which fever prevailed had not yet been properly sewered.

It can hardly be supposed that the privies and middens in different parts of the town became simultaneously productive of fever poison. At least it would be an assumption which could not be proved in the present state of our knowledge. It may, however, be worth while to ask if there was anything noteworthy in the atmospheric conditions preceding the outbreak. The severe frost ended on January 26. In the last days of January and the first half of February the mean daily temperature averaged about 40°. In the latter part of February it declined to 34°, but rose again at the beginning of March, and about the end of the first week, just when the fever certificates began to come in, the mean temperature rose to 50°.

The rainfall at Blackburn in the first half of February amounted to five inches: in the latter half of the month it scarcely exceeded half an inch: in the first week of March it was about one inch. One cannot perhaps find in these conditions anything likely to affect prejudicially the state of the air around privies and middens; though if Blackburn had derived its water supply from shallow wells, it would have been natural to suppose that the heavy rainfall of the early part of February had served to wash into them some of the surface filth that had accumulated during the frost of winter.

Remembering the situation and relations of the conduit which brings the chief part of the town supply from Pickup Bank to the Guide and Fishmoor reservoirs, one is led to ask if it was not possible that what we have imagined in the case of shallow wells might have really happened in the case of the shallow conduit. I am not in a position to prove that such pollution of the water actually took place at this time, but I think there is ground of suspicion that it may have done so.

I have mentioned that there had been, in the winter, several cases of enteric fever at Belthorn, the village on the crest of the hill, along the side of which the conduit is carried. From one medical man I heard of seven cases in January, four in February, two in March, seven in April, and three in May, all in this little village of Belthorn, which does not contain more than 300 or 400 inhabitants (part in Oswaldtwistle Urban District, and part in Blackburn Rural). From other medical men I heard of other cases. On inspection I found that the majority of these cases were clustered in the lower part of the village where was a spout of water by the roadside. This was the chief supply for all purposes. It was derived from a deep well in the sandstone rock, the position of which was indicated to me at a point in the road half-way up the steep village, only a few yards from a cluster of privies on each side of the road. The villagers themselves fully appreciated the danger of the situation. They pointed out to me that these privies were always dry, never needed emptying, that the fluid must go somewhere, that the rock was much fissured, and that its bedding sloped a little towards the well and the spout. In fact they had no doubt, nor had I, that the well must be polluted by the excreta from the dwellings above it. In the winter enteric fever attacked a family at a farmhouse on the hill slope between the village and the conduit of the Blackburn Waterworks. They drank water which was said to be derived by another pipe from the same well as that above-mentioned. In this case the excreta were thrown on to a manure heap near the house, and afterwards scattered with the rest of the manure over a sloping pasture which is separated by a deep lane and a grass meadow from the line of the conduit. The lane side drainage was said to be carried in a pipe under the conduit. From some of these Belthorn cases it is quite possible that infective matter may have leaked into the culvert in February and have been carried into the Guide and Fishmoor reservoirs. I shall have to show that contamination affecting the Guide and Fishmoor water would at that time have been imparted also to the supplies derived from the White Birt Colliery and from the deep well on Revidge.

Enteric fever at Belthorn.

But first I have to speak of a case of enteric fever, which appears among the cases reported to the Sanitary Authority in the latter part of February, the case of John Aspden, No. 124, Shorrock's Row, Guide. The certificate of his illness was dated February 22. The medical attendant assured me that the case was, from the first, one of unmistakeable enteric fever, promising at first to be severe, but afterwards taking a favourable turn and ending in complete recovery. At the time of my visit the man, a collier, was in full work. His wife worked all day at a cotton mill. They had come to live at Guide about three weeks after Christmas from Over Darwen, where the man had had typhoid fever three or four years before. They drank water from a spout in Guide seldom drunk from by the neighbours. The water is derived from a well under a house at the back of which are several privies. A specimen of this water has been analysed by Professor Frankland, who finds in it evidence of sewage contamination (*see* page 90). No other persons in Guide were ill with fever at the time of Aspden's attack.

Enteric fever at Guide.

The house in which the Aspdens live is the ninth from the bottom in the row of cottages which has been described above (page 76) as terminating just above the line of the water culvert, near its outlet (*see* plan). This case was not visited by the Medical Officer of Health, nor by the Inspector of Nuisances; the danger to the public health

attending the presence of a case of enteric fever so near the main artery of the water supply was overlooked; an unskilled labourer who works under the Nuisance Inspector was sent to the house with some carbolic acid powder. Aspden states that this disinfectant was used to discharges, which were then thrown into the privy, one of the row of privies that have their pits opening to the meadow through which the water culvert passes. Slops and rinsings of vessels undisinfected were thrown down a sink in the back yard, or thrown into the roadside gutter in front of the house. Either channel would carry them, as already described (page 78) immediately over the water-culvert, at points where it was evident on internal examination that fluid was in the habit of oozing into the culvert. Any such admixture, supposing it to occur, would be infinitesimal in comparison with the quantity of water flowing in the culvert, and that again, in comparison with the whole body of water in the reservoir which received it, would be but as a river flowing into the sea. It certainly taxes the imagination to suppose that so minute a portion of infected matter would suffice to give a poisonous taint to so large a body of water, unless it possessed the property of self-multiplication.

Distribution of conduit water in latter part of February 1881.

But now supposing the conduit water to be thus contaminated, let us see how, in the latter part of February, this water would be distributed.

In the first place there was evidence in the records of the water-levels in the several reservoirs, as kept by the waterworks manager, that from February 5 to 28, and again from March 4 to 31, the Fishmoor reservoir was being replenished from the conduit by the bye-wash described above (page 78). For this purpose the gate-sluice at the mouth of the bye-wash would be set half open so as to divide the stream coming from the culvert, turning part of it to Fishmoor and letting the rest run into Guide. So at that time any taint carried by the conduit water would be divided between Guide and Fishmoor. [Supposing any taint to enter the bye-wash from the tributary ditch (page 79) it would affect the water in Fishmoor, but not in Guide.]

In the next place there was evidence that for about a week February 12–19 the Guide water was turned into the Audley reservoir (*see* page 76) to supplement an extraordinary drain upon the latter, due to frost-burst service pipes, and taps left running to save the pipes from bursting. At the same time the Audley reservoir was being largely supplied from the White Birk Colliery. During this time, therefore, the Audley water would share (but in less degree) any taint that affected the water in Guide. The Audley reservoir, being very small in comparison with Guide or Fishmoor, might be expected to get rid of any such taint more rapidly than they; and it is a fact that in the north-east, east, and south-east districts which are supplied from Audley the epidemic appeared to subside about March 23–25, while in the west and south-west parts of the town, which are supplied from Fishmoor, it continued unabated through the month.

Lastly, there was evidence that during the weeks ending February 16 and 23 and March 2, the deep well on Revidge was being replenished from the Guide main, the mixed water being pumped from the well to the covered reservoir on Revidge top, and thence distributed to the northernmost part of the town.

Thus it appears that in the latter part of February every section of the water supply of Blackburn contained more or less of the water that had passed through the conduit under Belthorn and Shorrock's Row. Therefore, supposing the conduit water at that time to be the vehicle

of enteric fever infection, we can see how a general outbreak of fever in the early part of March in different quarters of the town might be accounted for.

The districts which suffered most severely were the southern, south-western, and western. These are principally, the two latter entirely, supplied from Fishmoor. The north-east, east, and south-east districts, which are chiefly supplied from Audley, were affected about equally but less severely than the other side of the town.

The northern district is supplied about equally from Audley, Fishmoor, Guide, and Revidge. It lies principally on the steep slope of the hill side, and appears to have suffered less than those before-mentioned. only half as much as the west and south-west districts, which are supplied exclusively from Fishmoor.

The main difficulty in the theory of infection by water lies in the singular immunity of the central district. This immunity is equally difficult to understand on any other hypothesis. Possibly the estimate I have employed of the population of this district, which is simply based on the number of burgesses in the ward, is much too high. It is unfortunate that no accurate data are available for the purpose, though at the recent census there should have been opportunity of learning the population of each enumerator's district. The area of the central district is largely occupied by the market place and market hall, the town hall, and public offices, the parish church and churchyard, all which greatly curtail the space available for dwelling-houses. The water supply to the dwellings is chiefly from Fishmoor; to the public buildings from Guide main.

Incidence of fever on different sections of water supply.

Leaving this difficulty where it stands, let us see what has been the relative incidence of fever on different sections of the town according to water supply. Here again we are at fault for want of accurate data of district population. Distributing the estimated ward population as fairly as I can among the four different sections of the water supply, I arrive at the following estimate of the number of inhabitants to each section: Guide, 1,960; Fishmoor, 65,100; Audley, 37,600; Revidge, 1,000. In these four sections the numbers of reported enteric fever cases have been as follows, month by month:—

—	Guide.	Fishmoor.	Audley.	Revidge.
1880.				
January	—	5	9	—
February	—	6	2	—
March	—	8	8	—
April	—	4	7	—
May	—	2	3	—
June	—	4	1	—
July	—	5	4	—
August	—	4	2	—
September	—	14	6	—
October	2	14	14	—
November	1	17	18	—
December	—	11	4	—
	3	89	73	—
Rate per 1,000 of population in the year 1880	1·5	1·36	1·9	—

—	Guide.	Fishmoor.	Audley.	Revidge.
1881.				
January - - - -	1?	3	2	1?
February - - -	1	7	5	—
March - - - -	5?	101	41	2?
April - - - -	1	40	20	—
May - - - -	4	15	9	—
	12?	166	77	3?
Rate per 1,000 of population in five months of 1881 - -	6·1?	2·5	2·0	3·0?

In the above distribution there is some uncertainty attaching to the numbers assigned to the Guide and Revidge sections respectively; for in some cases the supply was ambiguous, the same pipes being charged at one time from the one source, at another time from the other. This consideration, together with the smallness of the actual numbers, makes it unsafe to base upon them any positive conclusion regarding the Guide and Revidge waters. It is sufficient that the numbers, small as they are, are not at variance with those for the Fishmoor and Audley sections.

From these it would appear, if the population estimates are not altogether incorrect, that in 1880 the fever incidence was pretty equal on the different sections of the population supplied from different sources, with perhaps a preference for the section supplied from the Audley reservoir; but in 1881, and especially in March, the relative incidence is reversed, as between Audley and Fishmoor. This is quite in accordance with the theory that the March outbreak was due to contamination of the water in the conduit between Pickup and Guide.

Water from White Birk Colliery.

There is no reason to suppose that the contingent furnished to the Audley reservoir from the White Birk Colliery was independently charged with enteric fever poison. I was assured by the colliery manager (Mr. Thomas Taylor) that none of the miners had recently been ill. Mr. Taylor courteously took me down the mine, and showed me the main body of the water that flowed from disused workings. I have already mentioned that the danger of contamination does not lie here, but in a small contribution which comes from the heading where the miners are at work. However, there had been no case of fever among 14 families that take water from this source between the pump that lifts it from the mine shaft and the pump that forces it to the Audley reservoir. I think we may conclude that any infective property that may have attached to the Audley water was derived not from the colliery, but from the admixture of water from the Guide main.

Union workhouse.

Learning that the Blackburn Union Workhouse received a part of its water supply from the connecting branch between the Audley reservoir and the Guide main, I made inquiry there concerning enteric fever. There was, however, no history of enteric fever originating in the establishment, except in one case, that of a domestic servant who was admitted to the house on December 2, 1880, and taken into the sick ward on February 5, 1881. The average number of children in the house was about 140; of inmates, 750. They drink very little water,

but prefer buttermilk, of which there is a copious supply from a dairy attached to the workhouse. There is also on the grounds an independent source of water supply in a deep open pond which has gathered in a pit made by quarrying building stone for the workhouse. At the utmost we could not have expected a heavier incidence of fever on the workhouse than on the district supplied from the Audley reservoir, that is, in March, about one case per 1,000. The workhouse population being under 1,000, and consisting chiefly of elderly people, we need not be surprised that no case arose among them at that time.

Enteric fever at Cherry Tree and Lower Darwen.

The Fishmoor water is supplied to one or two outlying villages not included in the above-mentioned districts of the town. These are the villages of Cherry Tree, Lower Darwen, and Blackamoor, the last being very small.

At Cherry Tree, where the dwellings are of a good class, inhabited by higher artizans, and the drainage good, there had been at the end of February and in March seven houses invaded by enteric fever.

At Lower Darwen, about the same time, one medical man had had four cases of enteric fever in as many families.

At Blackamoor there had been a case at a farmhouse not supplied from the waterworks; but the place is not large enough to justify us in expecting so much as one case from a cause that gave only 1·5 per 1,000 in Blackburn.

It may here be noted that the incidence of fever in proportion to population was really very slight. It was not of marked severity in any particular streets, but was very generally diffused. This fact seems to show that the poison, by whatever vehicle conveyed, was largely diluted. Moreover it was observed by most of the medical men that the cases which they were called to treat were slow in declaring themselves and in developing the characteristic features of enteric fever, comparatively few of them proved very severe.

Conclusion.

These considerations all tell in favour of the theory, to which I strongly incline, though I cannot conclusively prove it to be true, that the cause of the March outbreak was a specific contamination of the water supply. How this can have come about may be gathered from the foregoing description.

* * * * *

December 1881.

App. A. No. 12.

On an Outbreak of Enteric Fever at Blackburn; by Dr. Airy.

Note of Analysis of Sample of Water.

Royal College of Chemistry, South Kensington Museum,
August 22, 1881.

Sir,

Herewith I enclose the results of analysis of two samples of water sent here from Blackburn at the request of Dr. H. Airy.

The water taken from the outlet of the culvert going into the Guide reservoir is possessed of a bitter taste owing to the presence of a large proportion of peaty matter. In all other respects it is of excellent quality for drinking, and being a very soft water it is also well adapted for washing, and all other domestic uses.

The sample from the spout at the back of the "Guide Pole House" Inn is clear and palatable, and contains only a small proportion of organic matter; but as this is almost wholly of animal origin, and as there is evidence of serious previous animal contamination, the water is dangerous for dietetic use. Being fairly soft it could, however, be used for washing.

I have also microscopically examined a small sample of water labelled "Water percolating into culvert near outlet at Guide." It contained a little suspended matter, but no moving organisms.

I am, Sir,

The Secretary,
Local Government Board.

Your obedient Servant,
E. Frankland.

Results of Analysis expressed in parts per 100,000.

Number of Sample.	Description.	Total Solid Matters.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates and Nitrites.	Total Combined Nitrogen.	Previous Sewage or Animal Contamination.	Chlorine.	Hardness. Temporary.	Hardness. Permanent.	Hardness. Total.	Remarks.
	Blackburn Waters. June 29th, 1881.												
5,215	From outlet of culvert going into Guide reservoir.	9·36	·453	·056	·002	0	·058	0	1·0	·2	4·4	4·6	Clear. Peaty taste. No poisonous metals.
5,216	From spout at back of "Guide Pole House" Inn.	22·20	·103	·053	·008	·706	·766	6,810	3·0	4·8	8·9	13·7	Clear. Palatable. No poisonous metals.

E. Frankland,
Chemical Department,
South Kensington Museum.

No. 13.

On an Epidemic of Enteric Fever in the Urban Sanitary District of Melton Mowbray, in connexion with the Sanitary Condition of the Town; by Dr. Blaxall.

On November 9th, 1880, the Registrar-General informed the Local Government Board of the occurrence of three deaths from enteric fever in Melton Mowbray; and on the 13th several cases of enteric fever having been reported in the town, the Urban Sanitary Authority applied to the Board to sanction the appointment of Mr. Roberts (one of the medical practitioners residing in the town) as Medical Officer of Health—that office having remained in abeyance since the preceding March when Dr. Buck, who held the appointment for a combined district that included Melton Mowbray, tendered his resignation. The Board sanctioned the application pending the re-appointment of a Medical Officer of Health for the combined district, and at the same time instructed me to institute inquiry into the circumstances of the outbreak in relation to the sanitary condition of the town.

Accordingly I proceeded to Melton Mowbray, and on arrival there, I placed myself in communication with the Clerk to the Authority, together with Mr. Roberts, the acting Medical Officer of Health, and the other medical men practising in the town, all of whom were good enough to give me lists of cases of enteric fever that had come under their treatment since the beginning of the year. The first case, dating from April 7th, occurred a month after Dr. Buck's resignation.

Melton Mowbray lies east and west along the north bank of the river Eye, having a gentle rise of about 15 or 20 feet to the north. The Scalford brook flows through the eastern boundary on its way to join the Eye. The town is overlooked on all sides by hills of various elevations. The geological formation is lias clay with argillaceous limestone at the base, underlying a porous soil of sand and gravel; but at the higher parts of the town the clay crops up to the surface. The subsoil is much water-logged, owing partly to the low-lying situation of the town, and partly to the damming of the river and brook at places for mill purposes, which by keeping the water at an unnaturally high level causes undue saturation of the soil. The town is also subject to serious floods; the highest known for some years occurring last July, when the water rose five or six feet in the houses in the lower part of the town. Inundations afterwards took place in September and October.

In 1871 the population was returned at 5,030. There are no special industries beyond the making of raised pies, which is carried on chiefly at two establishments, giving employment to several male and female hands; but Melton Mowbray being a great hunting centre, many of the men find employment in the stables.

Present Sanitary Conditions.

The sanitary condition of the town, I regret to have to report, is eminently unsatisfactory, with reference specially to the means of excrement removal and disposal, the water supply, and the drainage, while pigsties and slaughter-houses may be included amongst the many evils which here point to the want of efficient sanitary administration.

The privies mostly discharge into large and oftentimes uncovered cesspits sunk below the surface. Several of them are very filthy and

dilapidated, and they are occasionally to be seen in actual contact with inhabited dwellings, the walls of which are saturated with filth from them, while the air in and around the houses is pervaded with fæcal odour. Certain of the houses are provided with out-door closets which communicate with the sewers, but have no means for flushing. In the better class of houses the waterclosets are situated indoors, and have water laid on to them; but the soil-pipes, as a rule, are unventilated. The closets belonging to the British and Church Schools communicate with the sewers, and may be specially noted as affording examples of aggravated nuisance, consequent in a great measure on the want of proper provision for flushing them. The two belonging to the boys' schools are built back to back, and each contains four seats; while the girls' closets stand in separate yards. One of the latter is flushed by a rain-water tank, which at the time of my visit was empty, while the flushing of the other, as well as of the boys' closets, is dependent upon an arrangement in connexion with the school pumps. This arrangement is found to be not only ineffectual to the purpose of washing away the privy contents, but fraught with danger to the drinking water. It consists of a covered iron box under the spout of the pump, having inserted in one side, about two inches from the bottom, a small spout for the children to drink at, and in the other side a pipe to convey the water direct to the closets. The fact was overlooked that the pipe when empty forms a conduit for the foul air of the closet-pans, bringing it back to become absorbed in the water in the box, and thereby constituting a danger to the consumers of the water. One little fellow said he never drank the water of the school pump, as it smelt so nasty, and a man bore testimony to the same effect.

The water supply of the town is derived from wells which, I am informed by the Surveyor, vary in depth from 12 to 15 feet or deeper where there is clay at the surface. The sides are said to be steined with brick. In the process of sinking the wells much difficulty is experienced in keeping the water out, which is evidence of the extent to which the subsoil is filled with water. The public wells (nine in number) are sunk under the streets, and are much exposed to pollution by surface soakage and by infiltration into them from the surrounding subsoil. The danger is increased by the filthy practice of cleansing at these pumps carts that have been employed in the removal of night-soil. The Authority to put a stop to this have caused placards to be affixed to the pumps warning all persons so offending that proceedings will be taken against them.

The private wells are also much exposed to danger, being sunk in unwholesome proximity to privies and other contaminating circumstances. For example, a well belonging to a dairyman at Timber Hill, is about ten feet from a privy pit, which I observed to be full to overflowing, the contents leaking out from under the seat, while at a short distance off was a second privy, and near this a large accumulation of manure. The water of this well is used for dairy purposes.

Sewerage.—The Authority have given much attention to the question of sewerage, and have incurred considerable expense in their endeavours to improve the drainage of the town. Hitherto their efforts in this direction have been only partially successful, and the work has, moreover, been very imperfectly executed. As originally designed in 1862, the system consisted of glazed pipe sewers laid down the principal streets for the purpose of carrying off storm and surface water, together with the discharge of certain privies. These sewers all communicated with one main sewer, which, after a flat and somewhat long course, poured its contents into the river. This main sewer was found frequently to

become choked, causing almost endless expense to get it cleared or relaid. At last an engineer was consulted on the subject, and he devised a scheme for remedying the evil. Accordingly the Authority applied for a loan, which was sanctioned, to enable them to carry out the suggested improvements. These consisted in laying down a new main sewer, the lower end being formed into an elongated tank, in which the sewage accumulates at night. During the day it is pumped up to another tank, where it is treated with lime, the solids precipitating, while the effluent sewage is conveyed by pipes to the river. This plan has not, however, proved altogether satisfactory, the new sewer having sunk in places, and in consequence it is now being relaid on blocks of concrete. In connexion with the Scalford brook, to the eastward of the town, there is a flushing tank in relations with the main sewer; but all the other sewers are without any provision of the kind. The means adopted for their ventilation consists of man-holes fitted inside with charcoal trays, but these of themselves impede the free passage of air into and from the sewers, while their openings at the road level were without exception either choked with mud or filled with water. The man whose business it is to see they are kept in order told me that in summer they get filled up with road dust, adding, "they want seeing to every day." It is therefore evident that they do not properly fulfil the purpose for which they were designed. Again, the street gullies are carefully trapped, so that they do not assist in any way the circulation of air in the sewers. In a few instances where rain water pipes have been led into the sewers, the discoloration of the paint at the joints testifies to the foulness of the air that here escapes. The house drains are very imperfect, being subject to frequent choking, while the inlets are often untrapped. This, in the absence of proper ventilation of the sewers, is a matter of very serious moment, as offering facilities for the pent-up air to escape in the immediate vicinity of dwellings. In proof of the foulness of the gases so liberated I received numerous complaints of the stinks arising from the drain inlets. In the lower parts of the town I am told the storm water does not enter the sewers, but is led into ditches which have been culverted, and extend to the river.

Pigsties and Slaughter-houses, together with accumulations of refuse and manure, are matters demanding better supervision and care than is bestowed upon them in Melton Mowbray.

* * * * *

It may be gathered from the foregoing details that Melton Mowbray is furnished with plenty of conditions favourable to the development and spread of enteric fever.

Epidemic of Enteric Fever.

It appears that "fever" was present in this town in 1879, Dr. Buck stating in his annual Report for that year that two cases had been reported to him, also that a child had died of "simple fever." No mention was made of dates or localities, and it may be believed that other cases occurred which did not come to the knowledge of the Medical Officer of Health. Be this as it may, the introductory cases of the epidemic now in question date from the 7th of April, when fever attacked three persons, viz., a young woman on a visit to some friends in Leicester Street, and her brother and another young man lodging together in King Street. The disease was undoubted enteric fever of a virulent type, two cases proving fatal, viz., that of the young woman, who died after removal to her home, and the young man in King Street.

The girl's brother had severe hæmorrhage from the bowels. The brother and sister were in the habit of interchanging visits, but the other young man did not go to Leicester Street, nor had the sufferers been away from the town. These circumstances point to exposure to infection in or about the dwelling in King Street. Inquiry as to the probable medium went to show that both the drinking water and the milk were obtained from sources common to many other families who were exempt from fever; but it was found that the privy belonging to the house discharged into a cesspit which contained a great deal of excrement, fairly covered with ashes. The privy was very cleanly kept, but was offensive. Close to it was the trapped inlet of a drain, while at the entrance to the yard was a second inlet, untrapped and causing much nuisance. These facts suggest the possibility that the three cases above referred to owed their origin either to the air of the privy or the air of the sewer; and although there is no evidence at this period of the privy or the sewer having become specifically infected, still it is impossible to prove the contrary. Two fresh cases occurred on May 3rd and July 1st respectively. The first was that of a man living with his wife, three children, and a servant at Timber Hill, at the corner of Bentley Street, about 80 or 100 yards from the dwelling in King Street; but I could not hear of any communication between the infected families. The man's business took him a great deal away from home, visiting the country around, but there was no evidence of exposure to infection on these occasions. Close to the back door of this dwelling is a drain inlet, ineffectually protected by a bell trap, and near this a highly offensive midden-privy. The man, it appears, was specially intolerant of the stink, for it caused him much nausea; whereas the other members of the household did not notice it. The second case was that of a young lady living at Thorpe End. There were several other occupants of this house, as well as many employés on the premises, but hers was the only case of fever amongst them. The watercloset is situated inside the house, and communicates with the sewer. The soil pipe is unventilated, and the closet has no opening to the external air, the window being placed in the partition wall of an adjoining office room. There can be no doubt that this closet is an element of danger, but the lady, it would seem, was not peculiarly exposed to its injurious influence, her bedroom being some little distance removed. The sewer which runs in front of the house is complained of as giving rise to great nuisance, while in the yard in the rear is a cesspit privy, which at the time of my visit was being abolished. It will be seen by the foregoing that the infected families were living under conditions exposing them to risk of enteric fever; but beyond the fact—and this is not without significance—that the infected houses communicated with the same sewer, there was no ground for suspecting any particular condition as being specially implicated in the causation of the fever. With regard to the sewer connexion, however, it should be noted that the evacuations of the sufferers in King Street and Timber Hill were disposed of in the privies or buried. The further precaution was, it is said, taken by the King Street family to bury the water in which the infected linen was washed, but doubtless at the outset, and altogether as regards Timber Hill, such water was emptied down the drains, and most likely there was other opportunity of infection to the sewer. It is possible the lady's case (1st July) may have been due to this cause, the sewer air gaining access to the dwelling through the medium of the watercloset; but there can be no question that the case gave rise to much specific pollution of the sewer contents, the evacuations being disposed of in the watercloset, and so passing direct into the sewer. And this circumstance, it would seem, had a special bearing on

the outbreak that followed in the first week in August, when fever appeared in four other houses, all in direct communication with this particular sewer. From this time to the date of my inspection the disease continued to prevail, invading altogether, exclusive of the initial cases, 41 families, with 66 cases and 8 deaths, besides two fatal cases reported to have been contracted in the town and to have died elsewhere. Of the 41 families, four resided about half a mile out of the town, on the Asfordby Road, having distinct water supply and drainage. I therefore propose to treat of these separately. A fifth case may also be excluded, as the sufferer (a youth) had been on a visit to a distant town, and manifested the disease eight days after his return home, so the probability is he was exposed to infection elsewhere. The town epidemic therefore may be considered to include primary attacks in 36 distinct families. These, together with other particulars as to date, locality, &c., are, for the sake of convenient reference, given in the subjoined statement, where the four initial cases are likewise tabulated:—

Report on Enteric Fever at Melton Mowbray, by Dr. Buchanan.

Enteric Fever at Melton Mowbray.

40 Households Invaded. Total Cases 65.

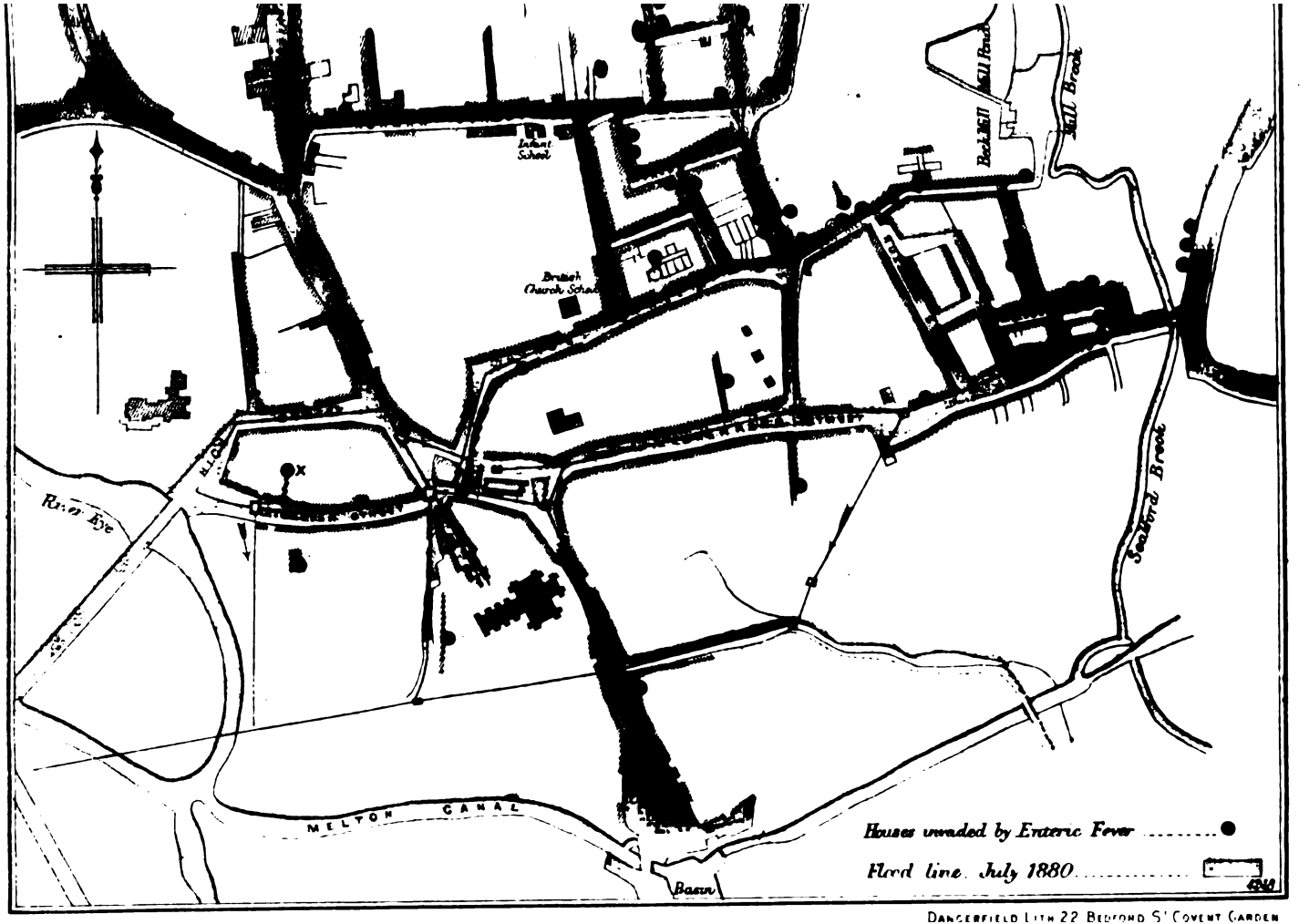
Week ending.	Locality of each Invaded Family.	Date of Primary Attack.	Aggregate No. of Cases.
Initial Cases.	King Street	April 7	2
	Leicester Street	„ „	1
	Timber Hill	May 3	1
	Thorpe End	July 1	1
Aug. 6	Burton End	Aug. 2	2
	Melbourne Street	„ 6	2
	„ „	„ „	2
	„ „	„ „	1
„ 13	Nil.	—	—
„ 20	Nil.	—	—
„ 27	Bentley Street	„ 25	2
Sept. 3	Nil.	—	—
„ 10	Norman Street	Sept. 5	1
	Church Yard	„ 8	1
„ 17	Nil.	—	—
„ 24	Nil.	—	—
Oct. 1	Norman Street	„ 25	6
	Timber Hill	„ 28	6
	Bentley Street	„ 30	1
	„ „	„ „	2
	Norman Street	Oct. 1	1
	Ann Street	„ „	1
„ 8	Nil.	—	—
„ 15	Nil.	—	—
„ 22	Melbourne Street	„ 18	1
„ 29	Asfordby Road (within town)	„ 23	1
	Timber Hill	„ 25	1
	King Street	„ 26	2
	Matthew's Yard, King Street	„ „	1
	Leicester Street	„ „	2
	Melbourne Street	„ 27	1
	Snow Hill	„ 28	1
	Ann Street	„ 29	4
	Pall Mall	„ „	2

Week ending.	Locality of each Invaded Family.	Date of Primary Attack.	Aggregate of Cases.
Nov. 5	Beck Mill Lane	Oct. 30	1
	Sidney Street	" "	1
	Sherrard Street	" "	1
	Pall Mall	" 31	1
	Sherrard Street	Nov. 4	1
	New Street	" 5	1
" 12	Ann Street	" 6	2
	New Street	" 7	2
After	Thorpe Road Yard	Dec. 1	2
	" "	" "	1
	" "	" "	1
	Timber Hill	" 8	1
	Leicester Road	" 15	1
		Total	65

It will be observed from this table that on three or four occasions there was a simultaneous appearance of cases in several streets, indicating some cause in special operation over an extended area. Thus it soon became possible to exclude, as being primarily concerned, two of the ordinary mediums of fever propagation, viz., polluted wells and unwholesome privies, the injurious effects of these being limited to persons living in their immediate vicinity or otherwise exposed to their circumscribed operation. In the Melton Mowbray epidemic the invaded families resided in various parts of the town, getting their water from different wells and frequenting different privies. Again, there was no community with regard to milk, some of the infected families not drinking milk at all, others getting it from various sources. On the other hand, the circumstances of the outbreak reflect grave suspicion upon sewer air as having been mainly concerned in the spread of the disease. It was found that the several streets which experienced the chief incidence of attacks occupy a portion of the town traversed by one particular line of sewers (see map); and with this line of sewers were connected the houses in which the initial cases occurred, and from which, as already explained, the sewer had certainly become contaminated with the specific material of the fever.

This suspicion receives confirmation from the fact that all the individuals attacked were found to have been peculiarly exposed to the influence of air escaping from drain inlets or closets. Thus, excluding the initial cases, 23 out of the 36 families had untrapped drain-inlets close to their dwellings; 9 had imperfectly trapped inlets, which were so offensive that the people used to throw chloride of lime down the drains to stop the stink. Besides this home-exposure to the injurious effects of sewer air, the opportunity of similar danger incurred at schools cannot in the case of 14 children be wholly overlooked.

Hence it is apparent that out of 36 infected families 32 were exposed to the influence of sewer air through the medium of untrapped inlets to drains. The remaining 4 had closets situated out of doors, but unprovided with means for flushing; an arrangement conducing to the escape of sewer air into the closets owing to the traps not being kept duly filled with water. Moreover the traps of the drains from these houses (like the other 32) were more or less defective.

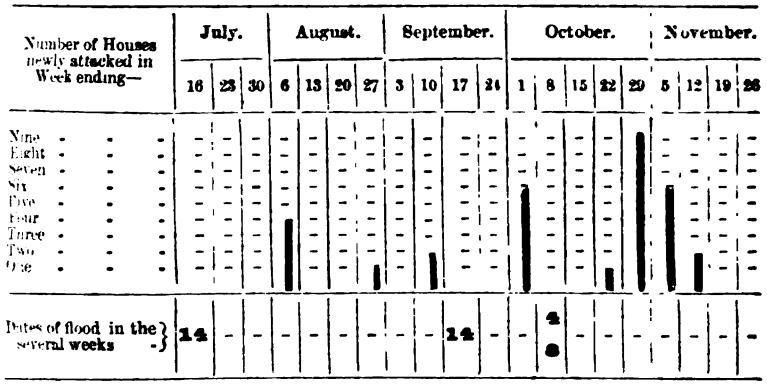


DANGERFIELD LITH 22 BEDFORD ST COVENT GARDEN

On referring to the accompanying plan showing the distribution of the fever, it will be seen that 3 of the families lived outside the infected area, but in each of these three cases the persons attacked had been in the habit of freely visiting relatives within the particular streets.

These three cases, therefore, although not occurring in the immediate fever locality, are properly included in that area, seeing that they are referable to precisely the same cause, viz., the infected air of one particular line of sewers.

In connexion with the sudden increase in the number of families invaded at certain periods, it is interesting and instructive to observe that this bears an intimate relation to the occurrence of the floods, a fact which will be better appreciated by a glance at the accompanying diagram, giving the dates of the floods, together with the number of houses newly attacked in certain specified weeks.



It will be observed that the floods took place on July 14th, September 14th, and October 4th and 8th, and that each occasion was succeeded at intervals of a fortnight or so by a sudden increase of fever in different streets. Thus the July floods were followed by cases in four fresh houses in the first week in August. In the next seven weeks only three houses were newly invaded. Then came the September floods, followed by the appearance of fever in six fresh houses during the week ending the 1st of October. After this no fresh invasions took place till the October floods, when (from the middle of October onwards) houses were newly attacked in each of four consecutive weeks, but no longer. This was the chief outburst, and in the second of these four weeks as many as nine houses were newly invaded.

Again, with regard to the marked influence exercised by the floods, it must be remembered that the bowel discharges of the sufferer at Thorpe End (initial case, July 1st) were disposed of in the watercloset, which communicated with the sewer. Hence the sewer at the time of the July flood was in an infective condition, and it is noteworthy that the four houses next invaded (week ending 6th August) communicated with this sewer, one family residing in Burton End and three in Melbourne Street, not far from Thorpe End. From these four houses there was a fresh infection of the sewer, and undoubtedly the air in it must have become more intensely poisonous, and poisonous for a longer distance up the sewer. So that when the September flood came, houses further off Thorpe End and at the higher levels about Pall Mall and New Street were exposed to increased danger from the escape of air from the imperfectly ventilated sewers into them or in the neighbour-

hood of them. Then for the third time, when the October floods found the sewers still more extensively infected, the risk to houses having drain-defects was still more widespread and considerable, and the notable outbreak at the end of October was the result.

The salient points of this epidemic may be summed up as follows:—

(1.) The fever was confined to a particular portion of the town traversed by one line of sewers, the contents of which had become specifically infected with the contagium of enteric fever.

(2.) The families invaded were exposed to the escape of the infected sewer air in the immediate vicinity of their dwellings.

(3.) The peculiarities in the incidence and succession of attacks arose from flooding of imperfectly ventilated sewers at the lower parts of the town forcing infected air through unguarded drain-openings at higher levels.

(4.) Other parts of the town beyond the immediate influence of the infected sewers were exempt from fever.

Enteric Fever in Asfordby Road.—This outbreak was confined to four families, residing about half a mile out of the town on the Asfordby Road, but within the limits of the urban district. The four cottages invaded were part of a row of seven, separated at the fourth cottage by a narrow passage, while at right angles to the north end of the row, with an intervening space of 100 yards or so right and left is a detached house on one side, and a row of four cottages on the other. Each row as well as the detached house is provided with distinct drainage, water supply and privies. The yard at the back of the seven cottages contains two washhouses for the use of the three and of the four cottages respectively, the washhouse for the four cottages being situated about the centre of the row, while near it is the pump which supplies the drinking water and which is common to the seven cottages. The water is complained of as being very bad, and as evidence of its impurity it is stated that on one occasion, when some horse manure had been deposited near the pump, the water became quite discoloured and stinking with the special stink of horse-dung, insomuch that the people could not drink it. Besides this pump one family has the privilege of getting water from the railway pumping station close by. The seven cottages are provided each with a midden privy built against the wall of the scullery. All were offensive and the effluvia from them pervaded the dwellings.

The introduction of fever into this locality would appear to be due to a man who came from Melton Mowbray about the end of August, to lodge with a family living in No. 1 cottage in the row. He was either suffering at the time from diarrhœa or was attacked within a day or two of his arrival. The diarrhœa continued to be persistent and considerable for some weeks, but he was not ill enough to consult a medical man. It appears that the occupants of the house he had left in the town all suffered in the same way, which circumstance together with the fact of his coming from a town where fever was present, excites the suspicion that his illness was enteric fever. While this must remain an open question, it is noteworthy that on the 24th of September the youngest child of the family with whom he came to lodge was taken ill with this fever, and on the 3rd of October two other children in this house were attacked, and subsequently the mother and the fourth child. The only infection to which the woman and her children would seem to have been exposed was the privy belonging to the cottage, and which the man made use of during his illness. With regard to the spread of the fever to other cottages in the row, here there is good ground for suspecting the drinking water to have been implicated. The evidence

of the woman is to the effect that during her children's illness the diarrhœa being considerable, their linen was very much soiled, and the water in which it was washed was emptied down the drain near the pump; and it would appear inevitable that the fever poison was thus conveyed to the well. On the 4th of November fever appeared in another house in the row, attacking two members of the family in one day, and subsequently two other houses were invaded, in all, four families and 16 cases. Now three of the four families habitually drank the water from this well, the fourth did so occasionally, but more frequently had recourse to the railway pumping station. Of the remaining three houses in the row that escaped, the family in one instance assured me that they never drank this well-water at all, but got their drinking water from the well belonging to the other row of cottages. In the second house the family had only been in occupation about a week at the date of my visit, and the third house was untenanted.

The other row of cottages and the detached house that got their water from other sources, and that had distinct privies, were exempt from fever. These facts, taken together, justify the conclusion that the man from Melton Mombray was the means of introducing the fever into the locality, and that its subsequent extension was due to the infected air of the privy, and to the drinking of the specifically polluted well-water.

In conclusion, the whole teaching of this inquiry points unmistakably to the epidemic of fever in Melton Mowbray being due to defects in conditions over which the Sanitary Authority can exercise control, viz., the ventilation of the sewers; the condition of the house drains; the state of the privy pits, and the circumstances of the water supplies. The floods unquestionably exercised great influence in the dissemination of the disease, but if the foregoing conditions had been wholesome the floods could not have been attended with the disastrous effects that they must now be credited with. Moreover, the town in its present unsanitary condition is a danger to the surrounding villages, as evidenced by my subsequent inquiry in the rural district, where several cases of enteric fever came under observation, undoubtedly contracted at Melton Mowbray.

It is quite within the competence of the authority to remedy the evils I have pointed out by intelligent and earnest employment of the powers with which they are vested by the Legislature, and unless early and efficient action be taken in the direction here indicated there is every probability now that the contagium of enteric fever has become so widely diffused, that the town will be subjected to the occurrence of isolated cases with occasional outbreaks of an extended character.

March 1881.

No. 14.

App. A. No. 14.

On an Outbreak of Small-pox at Bourne Bridge; by Dr. Airy.

On an Outbreak of Small-pox at Bourne Bridge, in the Ongar Union (Essex); by Dr. Hubert Airy.

In accordance with the instructions of the Medical Officer dated March 21, 1881, I made inquiry on March 28, and again on April 14, concerning a recent outbreak of small-pox (of which the Board had received information from a private source) in a family named Farrow, residing at Bourne Bridge, in the parish of Stapleford Abbots, in the Ongar Union.

The District Medical Officer, Mr. C. Sanders, of Chigwell, met me on the spot by appointment on March 28, and gave me information on various circumstances connected with the outbreak, and I have since had communication with the Inspector of Nuisances and the Relieving Officer.

The house occupied by the Farrows is a four-roomed, two-storeyed, weather-boarded, tile-roofed cottage, rented at 6*l.* a year, standing bare without fence or garden, about 80 yards from the nearest dwelling, and 100 yards from the public road, in a flat, swampy meadow at the bottom of a little valley between Stapleford Abbots and Havering-atte-Bower. The meadow is liable to be flooded. The cottage is approached by a causeway of faggots laid across the swamp. On the ground floor is the kitchen, about 8 ft. high and 15 ft. by 12 ft. in area, with boarded floor. A door leads from the kitchen into a back room of the same height, 15 ft. by 10 ft., with rough bricked floor—a damp, cold, dirty room, that serves at once as scullery, rubbish-hole, and slop-sink. Over these two rooms are two bed-rooms, reached by a stair from the kitchen. Adjoining either end of the cottage is a lean-to shed, one for cattle, the other for sheep, that are pastured in the meadow. There is nothing to keep these animals from the house door. There is a wooden privy belonging to the cottage, unsheltered by any fence, distant a few paces from the cowshed.

The following table gives the names and ages of the several inmates of the house, together with the main facts as to vaccination in relation to incidence of small-pox. It deserves notice that the four youngest children, who had all been well, or fairly well vaccinated, escaped the disease altogether, and that those who caught it suffered more or less severely according as their vaccination marks were less or more satisfactory and recent.

The first person attacked was the son, William, aged 19, who was taken ill, so that he had to leave work, on February 9. The "pimples" came out two days later, February 11. Within a few days (about February 15) his brother Frederick, aged 15, was taken ill. Thus far the serious nature of the disease had not been recognised. On February 17 the father, Samuel Farrow, was attacked, and his illness proving severe, application was made to the Relieving Officer (Mr. Thompson), and an order for medical attendance was taken to Mr. Sanders on February 19. Mr. Sanders called the same day, and found Farrow lying upstairs, without a fire, cold and comfortless. There was then no eruption to be seen. The man seemed to be suffering from severe cold. On the 21st one of the neighbours, a Mrs. Waylett, was called in as nurse. Farrow died on February 23, about 4 a.m. Mr. Sanders called again that day about noon. He was of opinion that Farrow's death was

partly due to the cold of the room in which he lay. The eruption was wholly suppressed, and the skin discoloured.

	Name.	Age.	Vaccination.	Small-pox.
	Samuel Farrow	54	Stated by Mrs. F. to have been vaccinated in childhood, but no marks seen by Mr. Sanders.	S. P. Eruption suppressed. Died on Feb. 23.
	Elizabeth „	42	Vaccinated in three places when seven years old; three smallish close-set scars, two foveated, the third smooth and elevated.	S. P. Severe attack. Recovered.
	Samuel „	21	Vaccinated; three typical marks	S. P. Slight attack, only a few pustules.
	William „	19	Vaccinated; three typical marks	S. P. A few pustules.
	Frederick „	15	Vaccinated; one fair mark	S. P. Smart attack, a good many pustules.
	Henry „	13	Vaccinated; one typical large mark and two smaller ones.	S. P. Slight. Few pustules.
Vaccinated by Mr. Sanders, F.V.	Ellen „	11	Vaccinated; three typical marks	S. P. Slight. Twelve or 14 pustules.
Vaccinated by Mr. Sanders, F.V.	James „	10	Vaccinated; four typical large marks.	No.
Vaccinated by Mr. Sanders, F.V.	Naomi „	5½	Vaccinated; five typical marks	No.
Vaccinated by Mr. Sanders, F.V.	Walter „	4	Vaccinated; three typical marks	No.
Vaccinated by Mr. Sanders, F.V.	Mary Ann „	8 mos.	Vaccinated; three small marks (a small sickly atrophied child).*	No.
	Mrs. Waylett	41	Uncertain; no marks seen when ill; refused Mr. Sanders' offer of vaccination.	S. P. Confluent. Death on March 14.

* This poor child was deprived of its mother's milk while she was ill, and though the milk speedily returned with her recovery, yet the child's stomach rejected it, and the child died, wasted away, on April 8.

The Relieving Officer, Mr. Thompson, called on the day after Farrow's death and gave the necessary relief to keep the family from starving. While the father lay ill, the eldest son, Samuel, 21, had a slight attack, so slight that he was able to walk to Chigwell to fetch the doctor on the day of his father's death, though he himself had the eruption upon him. Mrs. Farrow was taken ill on February 20, three days before her husband's death, and two of the younger children, Henry, aged 13, and Ellen, aged 11, were subsequently attacked with the disease in a mild form. Some of the neighbouring gentry, seeing that the Guardians in their sanitary capacity were doing nothing in the matter beyond supplying disinfectants, obtained the services of a trained nurse (Miss Short) from the St. Alban's Diocesan Nursing Institution at Witham. Miss Short came in on February 25, two days after Farrow's death. Mrs. Waylett remained to look after the children downstairs. A week later she (Mrs. Waylett) was taken ill. (She died on the 14th of March.)

The four rooms of which the cottage consists were now occupied thus:—Mrs. Farrow lay in the bedroom over the kitchen; the inner bedroom was given to the trained nurse; Mrs. Waylett lay in the kitchen; the rest of the family, nine in all, five of them convalescent after small-pox, were huddled in the wretched back chamber that opened from the kitchen. Slops are emptied at one corner of this room, where a hollow has been excavated in the rough brick floor, communicating, by a large hole broken through the base of the wall, with a corresponding hollow in the mud outside, whence the filth soaks away through the surrounding grass and its own accumulated sediment. A loose-made door in the further side of this room opens directly into the shed where sheep, more or less diseased, were kept.

I may mention that Mr. Sanders told me he had previously attended Mrs. Farrow for "typhus" fever and for puerperal fever in this same cottage.

Mr. Sanders visited the family every day as long as they required medical care. The Relieving Officer called once a week. The Inspector

of Nuisances (Mr. Stokes, of Ongar) also visited the place once, on the 19th of March. The extract from his journal relating to this visit is: "Very defective drainage, and the cottage very dirty. Notice served "on owner March 26, new drain to be constructed and cottage thoroughly "cleansed." Mr. Stokes informs me that he had strict orders from the Guardians not to go in the first instance, and that they had given the Relieving Officer power to supply disinfectants or anything else that was required.

Considering the isolated position of the Farrows' cottage, the severity of the disease in the case of Mrs. Waylett and Mrs. Farrow, and the inclemency of the weather, it was doubtless best to keep them where they were; indeed, the Medical Officer, Mr. Sanders, never recommended their removal; but with regard to the rest of the family the case was quite different, they were without proper accommodation, and they might properly have been removed, and not have been allowed to remain crowded with the sick, under such unwholesome conditions as I have described. The Guardians refused the use of the workhouse infectious wards for the reception of any of the family, and there is no other isolation hospital in the district.

This was a case in which the advice and supervision of an active Health Officer could hardly have failed to be of service. The Ongar Union is without a Health Officer.

The whole occurrence shows the need of an infectious hospital unconnected with the workhouse, with a properly qualified nurse, ready to receive a few patients at an hour's notice.

It is to be regretted that Mrs. Waylett did not submit to be vaccinated. Her life would certainly have been saved thereby. Mr. Sanders offered to vaccinate her, but she objected, saying that she had no fear of small-pox. There was no question of re-vaccinating Mrs. Farrow, for she already had the eruption of small-pox upon her when Mr. Sanders first perceived the real nature of the disease on February 23rd. The elder sons also had already had it; and Mr. Sanders regarded the younger children as being sufficiently protected.

Returning now to the first case, that of William Farrow; up to the 18th of January, a day which is everywhere remembered as the day of the great snowstorm, he had been at work, land-draining, at Barking Side, along with other labourers, 40 or 50 in all, who came from various places in the neighbourhood. The great snow-storm of January 18th put a stop to the work, and William Farrow remained at home for 12 days. On Monday, January 31st, he resumed work, though suffering from sore-throat, and continued at work through that week and for two days of the next, finally giving up on February 9th. Allowing an incubation period of 11 or 12 days, it seems probable that he contracted the infection of small-pox about January 28th or 29th, while he was staying at home out of work on account of the weather. I questioned him as to his doings about that time, but he declared that he had not been away from the hamlet. He did not remember meeting any one with "pimples" on face or hands, though he remembered while inside the public-house a quarter of a mile from his home seeing a woman-tramp outside who complained of feeling ill. He could not say on what day this happened. Going back to the time when he was at work at Barking Side, he remembered that some of the men employed there had left work ill, but did not remember that any one who worked near him had been ill. No second-hand clothes or other suspicious articles had been brought to the house.

If small-pox could be contracted from a person in whom the disease was still in the incubation stage, we might take it for certain that

Frederick and his father had caught the infection from William; but if this cannot be admitted, we must suppose that they all owed their infection to some common cause which was operative over a space of at least nine days. For example, it is possible that the clothes of some members of the family may have become infected by unnoticed contact with some person who had small-pox, and may so have become a standing source of infection at home. But there was no trace or recollection of any such occurrence.

As to a suggestion of the disease being in some way caused by some diseased sheep.—The facts were these:—A flock of seven sheep was kept in the meadow in which the Farrows' cottage stands. The meadow was flooded with rain and melted snow, and one of the sheep, trying to reach the shed adjoining the cottage, fell into a ditch and was drowned. This was on a Saturday, January 29th. William Farrow was at home at the time, and assisted in skinning the sheep. Several of the family partook of the boiled flesh of a leg and a shoulder. William only had a mouthful of it, but says that it was quite good to taste. His father and brother partook of it freely. The owner of the sheep, a Mr. Wright, of Havering, took the rest of the carcase home and had some of it cooked for dinner next day. None of his family sickened. We miss here the significant phenomenon of simultaneous attacks in several persons under the same conditions. There was no apparent sign of disease about this sheep; but some of the others were sickening about the same time with what was recognised by Mr. Wright's horse-keeper, as liver-fluke. Their wool came off, they lost flesh, seemed blind, staggered and fell. One of them died on the day when William first had the eruption of small-pox upon him (Wednesday, February 11th). The carcase, after being skinned, was left lying close by the end of the cottage, until it stank. It was partly devoured by dogs. (The dogs have shown no sign of disease.) The owner did not remove it, and at last the Farrows buried it in the meadow. William was ill at the time, and did not take part in this act. About a week later, another sheep died in the same way, and was left stinking near the shed, just at the time when the father, Samuel Farrow, lay ill with small-pox. Subsequently two more died, after Samuel Farrow's death, and while Mrs. Farrow lay ill. These last were more expeditiously buried. Thus five out of the seven sheep had died, one by drowning and four by disease. I saw the two survivors; one of them, which was manifestly ill, was caught and laid on its back to be examined. There was no obvious sign of disease on the skin, except that the wool came off easily, making the animal look patchy and ragged.

The two surviving sheep were seen by a veterinary surgeon, Mr. Nicholson Almond, of Ongar, who has courteously informed me that in his opinion one was "suffering from 'rot' or that disease of the liver caused by 'fasciola hepatica.' The other was apparently healthy."

We may certainly assume that the diseased sheep all suffered from the same disease, and this a disease which could not be supposed to have given rise to the outbreak of small-pox; and the agreement of the date of drowning of one of the sheep with the probable date of William Farrow's inception of small-pox can only be regarded as a coincidence.

The only persons, beside the Farrows, who had anything to do with the sheep, were Mr. Wright, his two sons, and his horse-keeper. None of these persons have been ill.

It would seem that for the actual cause of the outbreak we must look to some unnoticed contact with some person or article not known to be infected; or else to some wholly unsuspected channel of infection.

At a subsequent visit to the district, on April 14th, I learnt that another case of small-pox had recently occurred at another house in the same hamlet. The person attacked was Elizabeth Woolmore, the wife of James Woolmore, a labourer. The family owing to this attack was thrown on parish relief, and had been visited by the Relieving Officer.

It did not appear that the Inspector of Nuisances had visited the cottage.

Proceeding to Bourne Bridge, I found the Woolmores (husband and wife, and two boys aged 8 and 5 years) with a trained nurse, Ann Judd, (who had been called from Chelmsford by the Relieving Officer) occupying one half of a double weather-boarded cottage, by the road side, on the slope of the hill 200 yards to the west of the Farrows' and about 30 feet higher. In the other half of the cottage was a family named Lane, (husband and wife and seven children aged 15, 13, 11, 9, 5, 2½, and 4 months).

Mrs. Woolmore first felt ill on Sunday, March 27: the eruption was first noticed on Wednesday night, March 30. A private medical man had been sent for and came on the 29th, while the nature of the disease was still uncertain. He was again sent for and came on the 31st, as did also the Relieving Officer. Next day, April 1, the newly appointed District Medical Officer, Mr. Douglas, took charge of the case; and on that day the Relieving Officer sent to Chelmsford for a nurse, who came on April 2. On April 1 the infant of 4 months in the Lane's family was taken to Mr. Sanders and vaccinated in four places, producing four typical vesicles; and on that day week, April 8, Mrs. Woolmore's husband and the younger of their two children, together with the whole family of Lanes (except the child aged 2½ years, who was judged to be sufficiently protected), were re-vaccinated by Mr. Douglas from the arm of the Lanes' infant. The elder boy, Joseph Woolmore, aged 8, was not re-vaccinated: he bears four good scars of primary vaccination. The younger boy, Edward, aged 5, shows three smooth very faint scars, so faint as to be uncertain. His recent re-vaccination has produced one small compound vesicle and a string of four small separate vesicles.

James Woolmore, the father, shows one faint scar of primary vaccination, and two small vesicles produced by the re-vaccination.

Mrs. Woolmore has two fair primary scars. She remembers three. Possibly one may have been obscured by the small-pox eruption, which was confluent on her face and fore arms, and pretty thickly scattered elsewhere.

The nurse, Ann Judd, bears old marks of small-pox on her face.

Up to the 7th day of the re-vaccination, (April 14), when I saw these families of Woolmore and Lane, there had been no sign of any further spread of the small-pox; and I have since learnt that no fresh case had occurred up to April 22nd, by which time it might be assumed that they were out of danger. That none of them contracted the infection from Mrs. Woolmore before their re-vaccination took effect, may reasonably be attributed to the protection conferred by their primary vaccination.

Mrs. Woolmore's was a severe attack, but when I saw her, on the 18th day of her illness, she was recovering and was able to lift herself and sit up in bed. The scabs had come off her face, and were coming off her upper arms, but still remained on the fore-arms.

As regards the origin of the infection in this case there can be little doubt but that it was somehow derived from the older infection-colony at the Farrows' cottage, 200 yards away; but the mode of conveyance of the infection was obscure. No person was known to have passed between the Farrows' and the Woolmores'. Mrs. Woolmore herself went out charing at a house further to the west, away from the Farrows', where there was no danger of infection. She had not been along the road which passes nearest to (100 yards from) the Farrows' cottage, except on Sunday, March 20, a week before she was taken ill. She was very timid of infection, and had done her best to keep out of the

way of it. The popular belief was that she had "frightened herself into it."

Her husband, while speaking of the deaths at the Farrows' cottage, remarked that there was "a rare smudge up this way when they burnt "them clothes. The wind lay right up from there. It smelt so bad, "we came in." Mrs. Woolmore also had spoken of the offensive smell of the burning clothes. This burning took place about 6 p.m. on the evening of the day when Mrs. Waylett died, March 14. Mrs. Woolmore was taken ill on the 27th, after an interval which corresponds pretty closely with the usual incubation period of small-pox. The statement of Mr. Woolmore as to the direction of the wind on March 14 is borne out by the wind-record at Greenwich Observatory, as published by the Registrar-General in his Weekly Report. The record for that afternoon gives the direction of the wind as "E., E.N.E. and N.E." (The Woolmores' cottage lies to the west of the Farrows'.) There had been a previous burning of bedding on February 26, three days after Samuel Farrow's death; but on that day the wind lay in another direction, "S.W., S.S.W., S.S.E. and E.S.E.," and no offence was given to the neighbours westward.

It certainly seems highly probable that Mrs. Woolmore's infection was due to some dispersion of small-pox poison occurring in connexion with Mrs. Waylett's death. The Relieving Officer (Mr. Thompson) informs me that Mrs. Waylett died at 11 a.m. and was buried under his direction at 7 p.m. on the same day, the 14th of March. He says "the coffin was taken in an opposite direction to Woolmore's cottage, "*i.e.*, down the hill, and not to my knowledge had Mrs. Woolmore "been in contact with any linen, &c., that had been used in the case of "Waylett."

There remains no mode or medium of infection upon which suspicion can be fastened, except conveyance by the wind, over a distance of 200 yards, of infectious matter derived possibly from the ventilated sick-room, possibly from the clothes or bedding as they were brought out to be burnt, or as they were burning, or possibly from the dead body in the act of removal.

May 1881.

App. A. No. 15.

On an outbreak of Small-pox among Rag-sorters; by Dr. Parsons.

No. 15.

On an Outbreak of Small-pox among Rag-sorters at the St. Mary Cray Paper Mills, and on the Precautions which can be taken for preventing the Spread of Infection from Rags; by Dr. H. F. Parsons.

In April 1881 a sudden and extensive outbreak of small-pox occurred in the neighbourhood of St. Mary Cray among women employed as rag cutters at Messrs. Joynson and Sons' paper mills at that place. A report by Dr. Baylis, Medical Officer of Health of the West Kent combined district, indicated the probable source of infection to be in the rags in process of manufacture at the mill.

An inquiry was ordered by the Local Government Board, with a view especially to ascertain whether any precautions could be taken to prevent the spread of infection by means of rags. Dr. Ballard, who was engaged at the time on another investigation, has furnished me with some valuable notes on the questions involved, of which I have availed myself in the second part of this report.

Part I.—Outbreak of Small-pox at St. Mary Cray.

Description of Mills and Processes.—The mills of Messrs. Joynson and Sons, the well-known paper makers, are situated at St. Mary Cray, Kent, in the Bromley Rural Sanitary District. They employ several hundred hands, who work in spacious and well-ventilated rooms. The business consists in the manufacture of the finer qualities of writing paper, the materials employed being rags and the clippings of paper from envelope makers. The rags are of the finer classes, the lowest being what are termed in the trade "outshots." Some are of foreign origin, a portion of which come over ready cut; others are obtained from rag merchants in England, and a few from local collectors on the small scale. No rags had, however, been bought of local dealers since August 1880. The rags before sorting undergo a preliminary dusting, a process not in use at all mills. The "rough-dusters" are large revolving cylindrical sieves, with pegs on the inside which repeatedly catch up the rags and let them fall, thus knocking the coarser dust out of them. These machines are enclosed in wooden boxes, at the bottom of which the dust accumulates. They are placed in what was formerly a recess of the rag-sorting room, but which, since the outbreak of small-pox, has, by the advice of the Medical Officer of Health, been partitioned off from it, communicating therewith only by a door and by the outputs of the dusters, which are guarded by canvas screens. It is stated that much dust from the rough-dusters used to pervade the rag-house, but that since the partition has been erected the amount of dust in the air has been considerably reduced. The rag-house is a large shed with an iron roof in three spans, supported by rows of pillars. It is ventilated by openings along the crown of each span, and also by a series of louvres near the ground level, opening into another shed, along the whole length of the side opposite to the dusting machines. In the rag-house about 160 women (two-thirds of whom, it is estimated, are under 30 years of age) are employed in sorting and cutting up the rags; there are in addition about three men, who are employed as foremen, or in conveying rags from one part of the building to another. The

latticed tables or "hurdles" at which the women work are arranged in double rows with passages between them; each double row having a partition along the middle, on either side of which the tables are arranged. On each table is fixed a large scythe-like blade in an upright position with its edge away from the operator. Each woman has to fetch rags for herself from the duster in baskets. Standing at her table she takes the rags one by one, and after removing buttons, seams, &c., cuts them in pieces and throws them into a bin that has separate compartments for each quality.

After having been cut, the rags are placed in an apron, *i.e.*, a kind of elevator with two endless bands which revolve side by side carrying the rags between them, by which they are conveyed from the rag-house to a room on a higher storey, where they undergo a second and more thorough dusting, passing first into the "willow" (a machine with prongs revolving in opposite directions), by which they are threshed, and then into a revolving cylinder similar to the "rough duster."*

After this second dusting the rags are conveyed in barrows to the rag boilers. These are large cylinders laid horizontally, and revolving round their axes. Each cylinder has on one side a manhole capable of being closed with a tightly-fitting lid; each is also provided with a pipe for the admission of high-pressure steam, and another for the escape of air; these pipes enter by the axle but do not turn with it, and are bent so that the former reaches nearly to the bottom, the latter nearly to the top of the interior of the cylinder.

The cylinder being brought round to such a position that the manhole is uppermost, and immediately under an opening in the floor above, a charge of rags is inserted, water and caustic soda added, the lid fixed, the cylinder made to revolve, and steam admitted until the rags are sufficiently boiled.

It may be taken for granted that no morbid infection which the rags may contain can retain its activity after exposure to prolonged boiling and the action of caustic alkali, and it is therefore unnecessary to follow the process of manufacture further.

Outbreak among Rag Workers.—It is stated by some of the older hands at the mill that small-pox occurred among the rag cutters there about 20 years ago; no mention of this outbreak, however, is made in Dr. Bristowe's "Report on the rag trade in relation to infectious disease" in the Eighth Report of the Medical Officer of the Privy Council (1866), although Messrs. Joynson's mill is there alluded to. No cases of small-pox are known to have occurred among the work-people of late years until the middle of April in the present year (1881), when a number of persons engaged in the rag-house were taken ill within a few days of each other. There was no concurrent outbreak among persons unconnected with the mill.

---

* A rough analysis of three samples of rag dust showed its composition to be in 100 parts—

Moisture (dried at 212°) -	- 6
Organic matter (mostly vegetable fibre) -	- 74
Mineral matter (mostly silica) - -	- 20
	100

Of the three samples two were from the "rough dusters," one being the refuse of fine, the other of coarser rags; the third was from the "finishing duster." Although differing considerably in fineness and colour, their general chemical composition was almost identical; except that the dust from the finishing duster contained a slightly larger proportion of mineral matter.

App. A. No. 15.

On an outbreak of Small-pox among Rag-sorters; by Dr. Parsons.

From a list of the cases with which I have been furnished by Dr. Baylis, it appears that 25 cases began between April 16th and April 23rd, the appearance of the eruption being taken as the date of commencement, viz.,

April 9th - - - -	1
April 16th - - - -	1
April 17th - - - -	4
April 18th - - - -	2
April 19th - - - -	12
April 20th - - - -	2
April 23rd - - - -	1
Exact day not given - - -	2
	25

The length of the period of incubation in small-pox being very generally 14 days, it would appear that the above-mentioned cases, or most of them, could not have contracted infection from others previously affected, but that their illnesses must have been due to a cause or causes acting simultaneously, or nearly so. The fact of almost the whole of the patients having worked in the rag-house either as cutters or in attending to the "apron" and "dusters," the workers in other rooms of the mills being, with one exception, then unaffected, shows that the source of infection was in that particular room. What was this source? To this question only two answers seem to suggest themselves as possible. Either (I.) the infection might have been derived from some person present in the room, or (II.) it might have been brought there in the materials operated on.

(I.) On this point, the result of my inquiries, as well as those of Dr. Baylis, was that no person suffering or having suffered from small-pox is known to have been in the room before the first case occurred on April 9th. The possibility of an extremely mild modified case of small-pox having escaped notice has of course to be taken into account. There were, indeed, a few other cases in the district prior to or about the time of the outbreak at the mill, all of which could be traced directly or indirectly to infection from outside the district. The following are the particulars of these cases:—

1. Agnes P., 19, domestic servant, St Mary Cray; eruption, March 8th. Had been in London (Old Kent Road) for three days a week or two before. Removed to hospital March 11th.
2. Ann P., 7, sister of last. At home with her when she was ill; taken ill a month later, and removed to hospital on April 14th.
3. G. C., a tramp, presented himself to the relieving officer at St. Mary Cray, on April 11th with the small-pox eruption newly out upon him. He had walked from a farm about three miles distant where he had slept for three nights in an outbuilding, having previously come from Deptford. He was sent into the union hospital, where he remained for a fortnight, when, being wanted by the police, he absconded, and has not since been heard of.
4. Mrs. J. O., 41, Sidcup. Taken ill on April 22nd, three days after her arrival in district from Deptford.

The only communication between any of the above cases and the mill, so far as could be learnt, was that a cousin of 1 and 2, living in the same lane, and who used to play out of doors with other members of the family, but had not been into the house, worked at the mill, but not in the rag-house, and that a girl working in the rag-house, who did not have small-pox herself, had visited Ann P. on April 14th, the day that

she was removed to the hospital, and perhaps on other previous occasions. The foreman states that the earliest cases of small-pox were young people who were in the habit of associating with this girl in the dinner hour, though they did not work near her. Among these was a girl E. F., who was taken ill on April 9th. This girl, who lives at Orpington, had not been away from home for some time previously to the outbreak, and had not been herself in communication with any cases of small-pox. There is some discrepancy as to the exact date of her illness.

The circumstances above-mentioned can hardly be considered sufficient to account for the outbreak, its date and sudden character being taken into consideration.

(II.) It seems more likely, therefore, that the source of infection is to be looked for in the rags upon which the persons affected were working. Suspicion at first fell upon a particular sample of foreign rags, which it was reported were of a dirty and offensive character, containing poultices, bandages, and a stocking fouled with human excrement, the inference being drawn that these rags were the refuse of a hospital receiving small-pox patients. Further inquiries did not substantiate the case against these particular rags. The rags in question, which had come from Trieste, had been in stock 12 months, and had been in cutting on and off for nine months before the outbreak. I am assured by the manager and several of the overlookers that although not of the cleanest class, they were not more foul than English rags of the same sort, and that there was nothing about them to lead one to suppose that they had been used by the sick. On inquiring of the women who had complained of the quality of the rags, all that I could learn was that they had a peculiar smell, compared by one witness to paraffin oil, and that the stocking above mentioned had been found among them. It is stated that there is a prejudice among the cutters against this particular sample of rags, as they are dry and dusty, and less readily cut than English rags, so that less money can be earned working upon them. Poultices and bandages are, I am told, occasionally found in all rags, but the cutters are not obliged to cut any rag to which they may object; such rags are laid aside, and at the end of the day are removed to the fields for use as manure. It may be added that poultices and bandages are not applications of common use in the treatment of small-pox; that surgical cases, such as would be the most likely to want poultices and bandages in their treatment, are not commonly treated in the same hospitals as small-pox; and that in all well-regulated small-pox hospitals infected rags are burned, or at least thoroughly disinfected before being disposed of. Of the cutters affected with small-pox, only four had cut any of the foreign rags within 14 days before leaving. The other rags in use at the time were English rags collected at London, Bristol and other places. The manager states that they had had large quantities of rags of late from London (where it will be remembered that small-pox has been extensively prevalent for some time past), and that their stock of rags being then low, these had come into use unusually quickly. He thinks that probably rags would never come to be worked up in less than a month after they were cast off.

It seems, therefore, that, assuming the infection to have been conveyed by rags, it is quite as likely, or more so, that the infected rags were of home as of foreign origin.

As regards the mode of reception of the infection, it appears probable that it was communicated by the inhalation of infectious dust rather than by the mere contact of the hands with the dry rags. Dry small-pox matter is little likely to be absorbed by the uninjured skin, but there

can be no doubt that deposited in the form of dust upon the moist mucous membrane of the throat and air passages, and inhaled into the lungs or swallowed with the saliva, it is under conditions most favourable for absorption. The dust is given off both in the dusting machine and in the handling and tearing of the rags by the individual workers.

Subsequent Outbreaks.—The patients first affected with small-pox were for the most part removed for treatment, as soon as the nature of the cases was manifest, to the union hospital, but some were treated at their own homes. After April 23rd, during an interval of 12 days, no fresh cases occurred, but on May 2nd to 7th a second batch broke out, and after another interval of nine days a third batch. The dates of eruption of these later cases were :—

May 2nd	1
May 3rd	1
May 4th	2
May 5th	3
May 7th	2
	9
May 16th	4

Of the cases in the second batch only four had worked in the rag-house or about the dusting machines. The remainder either did not work at the mill at all, or worked in other departments, but they belonged to families in which cases of the first batch had occurred. Of the four cases on May 16th, two worked near together in the paper-making room, the other two had not been at the mill for a long time. In the last batch of cases the disease was probably contracted by personal communication with previous cases, either at the mill during meal times or at home, as the parties lived near together. All the cases of the second and third batches probably owed their origin to direct infection from previous cases, and not to infected rags.

Part II.—General Considerations.

Frequency of Infection by Rags.—Dr. Bristowe, in his report before-mentioned, after visiting 86 paper mills scattered in different parts of England, arrived at the conclusion that small-pox and other infectious diseases were very rarely introduced into paper mills by rags, but at the same time that their introduction was possible, and occasionally did take place. In a supplement he gave particulars of several instances of small-pox attacking rag workers in paper mills.

During the progress of the present inquiry, this Department has received information of a small-pox outbreak, similar in character to that at St. Mary Cray, at a paper mill at Maidstone in April 1881, and also of four recent cases, one in the Oakworth Urban, two unconnected with each other in the Holywell Rural, and one in the Shaftesbury Urban District, in which a person working on rags has been attacked with small-pox, no communication with any previous case being discoverable. Particulars of these cases are appended to this report (page 121).

Other similar cases are recorded in the following annual reports of Medical Officers of Health :—

Linton Rural Sanitary District, 1875, by W. Armistead, M.B.
Canterbury Urban Sanitary District, 1875, by H. E. Hutchings.
Malling Rural Sanitary District, 1876, by C. O. Baylis, M.D.
Bradford (Yorks.) Urban Sanitary District, 1879, by H. Butterfield.
Taunton Rural Sanitary District, 1880, by H. J. Alford, M.D.

Wakefield Rural Sanitary District, 1878, by W. Dyson Wood.

Maidstone Urban Sanitary District, 1880, by M. A. Adams, F.R.C.S.

Watford Rural Sanitary District, 1880, by C. E. Saunders, M.D.

Small-pox, attributed to rag infection, has also occurred repeatedly at the Woodside paper mills, near Aberdeen.

In all these cases small-pox has been the disease of which the origin has been attributed to rag infection. This coincides with the opinion of Dr. Bristowe that small-pox is the form of infectious disease most likely to be carried by rags.

The possibility of persons engaged in the rag trade contracting infection from rags is admitted by foreign writers.

Tardieu ("Dictionnaire d'Hygiène," Art. *Chiffoniers*) mentions itch as the disease to which rag-pickers are especially liable.

Pappenheim ("Handbuch der Sanitätspolizei," Art. *Lumpenindustrie*) speaks of persons engaged in the rag trade as coming in contact with contagia of all kinds.

M. Gibert, of Marseilles (quoted in "Revue d'Hygiène," July 1879, p. 596) has shown that small-pox and other infectious diseases have frequently been caused at that town by the rag trade, inland and foreign, and by the sale of garments used by the sick. He quotes also the similar observations of M. Oidtmann, of Leipzig ("Gesundheitswacht," 1877), and of Dr. Lewis, of Wartentown, New York ("Marseille Médical," Nov. 1875). The latter author considers that not only small-pox, but other eruptive fevers have been transmitted by rags.

M. Van de Velde, of Antwerp ("Annales d'Hygiène," Sept. 1880, p. 272) admits the transmissibility of contagious diseases by articles of clothing coming from the sick, but states that no epidemic has ever been caused in Belgium by the unloading, transport, or working of the foreign rags from all countries, which are imported there on a vast scale.

The "Revue d'Hygiène" of May 1880, p. 439, mentions an outbreak of small-pox at Abenheim, in Rhenish Hesse. The first cases were five women who worked in a rag factory, cutting and sorting rags. These rags were found to have come from Marseilles, where small-pox was raging at the time.

M. Ruysch, of Maestricht, informs the same journal (loc. cit., and p. 748) that in 1878–80 he observed many cases of small-pox among the workwomen at a paper-mill who had handled rags coming from certain places in Belgium where small-pox prevailed epidemically.

A peculiar disease has been observed among rag workers in Lower Austria ("Revue d'Hygiène," 1879, p. 79), attended with lesions of the lungs and being rapidly fatal. It is said only to attack those working on white rags.

It may be asked how it is that infectious diseases are not more frequently conveyed by rags. Dr. Bristowe suggests the following considerations in reply:—

1st. Hospitals in which infectious cases are treated do not, in this country at least, sell their infected rags, and in private households it is only among the ignorant and careless that such articles would be allowed to pass into the market, since to do so is now a breach of the Public Health Act.

2nd. Before the rags reach the paper mills they have been sorted two or three times and exposed to the atmosphere, and have thus lost some of the deleterious qualities which they may have originally possessed.

3rd. The preliminary dusting which rags undergo in some mills must tend to deprive them of any infection which they may have

retained, unless the dust shaken out of the rags be allowed to diffuse itself in the air of the workroom, in which case it would favour the spread of disease.

4th. It is only during the preliminary stages of paper making that danger can exist. The boiling and chemical treatment to which the rags after cutting are subjected render them in the later stages of manufacture quite innocuous.

To these I may add—

5th. The rags are usually kept a considerable time in stock before use, so that many months must commonly elapse, especially in the case of foreign rags, between their being cast off and their coming into the cutters' hands, and, judging from the analogy of vaccinia, any infective matter which they may contain may be expected to lose activity by keeping.

6th. Only one class of paper mills incur much risk of infection being introduced into them by rags. These are the mills where the finer classes of paper, as writing paper, are manufactured. Brown paper and other coarse papers are made of old ropes, bagging, and other materials not likely to be infected. It is true that the dust which is shaken out of the rags of which finer papers are made is commonly sent to the manufacturers of brown paper; but this item is comparatively trifling in amount, and it does not undergo any manipulation. Printing papers and inferior writing papers are made of straw, wood, esparto grass, &c., with a certain proportion of rags according to quality. Thus, in mills where the coarser kinds of paper are made the chances of rag infection would be comparatively small.*

7th. In any case the proportion of infected to uninfected rags must be very small, and seeing that the majority of rag workers are probably more or less efficiently protected against small-pox by vaccination, and against measles and scarlet fever by previous attacks in childhood, it will be comparatively rarely that an infected rag comes into the hands of a susceptible person. Even should it do so, mere contact with the unbroken skin, as before remarked, would probably not convey the disease.

It is considered by paper manufacturers that the fumes of chlorine, sulphurous acid, &c., with which the air of a paper mill is often impregnated, have a disinfectant effect. It is not probable, however, that such gases can exercise much (if indeed, any) effect in destroying infective matter unless they are present in the air in such a state of concentration as to render it irrespirable.

It is not only the workers who come in contact with rags in paper mills who are exposed to infection. Persons engaged in the preliminary

* The following classification of paper mills in England and Wales in 1880 is taken from the "Paper Mills Directory," 1881:—

Mills making	writing papers (hand-made) - - -	23
,, ,,	writing papers (machine-made) - -	21
,, ,,	writing papers (engine-sized) - -	20
,, ,,	printing and news - - - -	74
,, ,,	long elephants - - - - -	16
,, ,,	cartridges - - - - -	45
,, ,,	grocery papers, white and coloured - -	56
,, ,,	small hands - - - - -	47
,, ,,	brown papers, all kinds - - -	159
,, ,,	milled boards - - - - -	15

The total number of mills at work in England and Wales in 1880 was 297, many mills making more than one class of papers. The tendency, however, is said to be to restrict the number of sorts made at each mill, and to settle into fewer and regular kinds.

Thus the mills where the finer classes of writing paper are made form but a small proportion of the whole number.

sortings which rags undergo at the hands of collectors and rag merchants (some of whom employ large numbers of hands) may also suffer, as in the Wakefield cases referred to. Indeed, it might be supposed that such persons having to do with the rags nearer to the source would be exposed to more risks than the cutters in paper mills. That they do not suffer more is probably due to the manipulation which the rags undergo in their hands being less than that by the cutters.

Precautions.—Under this heading several questions arise.

I. What measures are available, in the way of disinfection or otherwise, to prevent the spread of disease by rags?

II. Are there any particular classes of rags in respect of which it is especially desirable that such measures should be adopted?

III. Should such measures be made compulsory, and if so, upon whom should the onus fall?

I. What measures of precaution are available to prevent the spread of disease by rags?

The measures which have been adopted or recommended fall under the following headings*:—

A.—Vaccination.
B.—Ventilation and prevention of dust.
C.—Disinfection of rags.

A.—As regards small-pox, which it would appear is the disease most liable to be introduced by the agency of rags, we have in vaccination an obvious and efficient protection. It should be made a condition of employment at paper mills and rag warehouses that every new hand should be vaccinated or revaccinated as the case may be, unless he have already been revaccinated since puberty. Old hands should also be urged to avail themselves of this protection if they have not already done so.

B.—Since there is reason to believe that infection is conveyed into the human system in the form of dust, any measures that will diminish the dustiness of the air will tend to prevent the spread of infection, as well as to benefit the health of the operatives in other ways. Ventilation of the work rooms should be carefully attended to. The bales of rags should, if possible, be unpacked in the open air. A preliminary dusting of the rags is to be recommended, but the dusting machine should be so placed that the dust will not fly into the workrooms. In some cases a ventilating fan may be useful to draw off the dust from the machines.

C.—Rags in their conversion into paper undergo two processes, either of which would effectually destroy any infectious matter which they

* The following conclusions were adopted by the Assemblée Nationale Scientifique d'Hygiène et de Médecine Publique de Bruxelles in 1880:—

1. To recommend the public not to sell clothing or bedding which have been used by patients suffering from infectious diseases without having had them conscientiously disinfected.
2. To forbid hospital establishments to sell old clothing or rags which have been used by the sick, and to compel such articles to be burnt.
3. That police regulations should be issued forbidding the storage on the small scale of rags unless washed and disinfected.
4. That only such rag stores should be tolerated as are situated in proper positions, and comply with hygienic requirements.
5. That rag stores, however small, should be classed among offensive and noxious establishments.
6. That paper mills, and especially those in which the sorting is done in the dry state, should be compelled to submit the rags to suitable disinfection, and to maintain in the rooms thorough ventilation.
7. To collect exact statistics of the mortality among rag-workers.

might contain, viz., boiling with caustic soda at a steam heat, and bleaching with chlorine. If either of these processes could be made to precede the sorting, the desired end would be attained, but unfortunately manufacturers state that this is impracticable or at least would seriously interfere with their operations, for the reason especially that wetting the rags would fix the dirt in them so as to prevent its being shaken out in the dusting machine.

If so, it follows that if disinfection of rags previous to sorting be deemed desirable, either generally or in any particular case, some process must be adopted for that special purpose.

In order for any disinfecting process to be applicable to rags, the requisites are, that while effectual in destroying any infectious matter that may be present it shall not injure the texture of the rags, nor interfere with the subsequent processes of manufacture, also that it shall be cheap, and shall not necessitate much handling of the rags. For the reasons above given, any processes involving the wetting of the rags, as boiling or the use of liquid disinfectants, are considered inapplicable. Some manufacturers say that the colour would be likely to be injured, but all agree that the rags would require to be dried before sorting, which would involve extra expense. The processes which seem to promise most are :—

1. Prolonged exposure to air.
2. Chemical disinfection :—
   (*a.*) By gases, as sulphurous acid.
   (*b.*) By pulverised solids, as carbolic powder.
3. Disinfection by heat :—
   (*a.*) By hot air.
   (*b.*) By high pressure steam.

1. *Prolonged exposure to air.*—This is the plan formerly adopted abroad for the purification of rags subjected to quarantine. Mr. Allen, of the Ivybridge paper mills, states, in answer to Dr. Ballard, that on one occasion he received a quantity of lousy rags, and these he spread abroad upon a field adjoining the works, exposing them there for some time to the weather. He does not think that this measure would be generally practicable, since few paper mills have available land close at hand, being generally placed in narrow valleys for the sake of water-supply and water power; while to take land for the purpose at a distance would involve much expense in carting, unpacking, turning over, and repacking. The extra handling required would be an objection in a sanitary point of view, and it could only be done in fine weather.

2. (*a.*) *Disinfection by gases.*—Messrs. Fisher & Co., paper manufacturers, speaking from a manufacturer's point of view, make the following suggestion : "We are not aware whether sulphur burnt in a "closed room in which there was a pile of rags, say of two or three "tons or smaller quantities, would be sufficient to disinfect the pile, but "if so, it might not be a difficult matter for every marine store dealer "who buys rags from small collectors to have some room or outhouse "specially kept into which all the rags he has bought during the day "may be placed, a small quantity of sulphur lighted, and the room "closed for some hours." The points in favour of this process are that it is simple and cheap, requires no expensive apparatus, and hence is within the reach of the small dealers into whose hands the rags first come ; but in order to expose them to the sulphurous vapour, it would be necessary to spread out the rags on sieves or hang them on a line, as the vapour would not penetrate into the interior if they were piled in a heap as described. Moreover, it is possible that the process might be found to deteriorate the quality of the rags. Sulphurous acid, on

exposure to the air, becomes in time converted into sulphuric acid, which might render the rags damp and rotten. A paper mill manager informs me that he has tried a dilute solution of sulphurous acid for bleaching, but found that it "burnt" the fibre and injured the colour of the manufactured paper, especially on keeping. Messrs. Fisher & Co. admit this danger, and Mr. Allen states that the use of acid disinfectants would be very objectionable to the paper maker. The same objections, he says, would apply to chlorine gas, which would be sure to be acid. These points must be decided by experience.

(*b.*) ***Disinfectants in the form of powder.***—Since the outbreak of small-pox at Messrs. Joynson's mill, by the advice of Dr. Baylis the firm have taken the precaution to mix carbolic powder with the rags as they are unpacked from the bales, and before they are passed through the "rough-dusters." The manager states that he prefers this to any plan of fumigation or disinfection by heat, since he knows the exact cost, and has not to run any risk of further loss by deterioration of the rags in the process. The carbolic powder is guaranteed to contain 15 per cent. of carbolic acid, and costs 12*s.* per cwt. It is used in the proportion of 1 lb. of powder per cwt. of rags, the cost therefore being about 2*s.* 1½*d.* per ton of rags. Dr. Baylis believes that by the use of carbolic acid in this way the dust from the rags, which he considers to be the main agent in the spread of infection, may be effectually disinfected, though he would recommend the use of a larger quantity of the powder, enough to equal in amount two-thirds of the dust contained in the rags, which is about 4 per cent. or 90 lbs. per ton. Dr. Baylis considers it improbable that the infected rags in a bale ever exceed one-tenth of the whole; and he estimates the amount of infected dust as not more than 9 lbs. in a ton of rags. From a large experience he believes that the excretions of the sick are effectually disinfected when carbolic acid is mixed with them in the proportion of one part of the acid to two parts of the dried solid matter in the excretions. Used in the proportions recommended by Dr. Baylis, carbolic acid would be present in the ratio of one part to each part of possible infected dust, or double the proportion which he has found to be effectual. In the proportion actually used at the mills, the carbolic acid would be to the possibly infected dust as 1 to 3.

It will be observed that the cogency of the above train of reasoning depends not only on the accuracy of the numerical data, some of which it would be difficult to verify, but also upon the validity of certain tacit assumptions, as that the carbolic acid is evenly diffused throughout the mass of material, and that it is brought, in an adequate state of concentration, into sufficiently intimate chemical contact with the material upon which it is required to exercise its powers. The first point I am assured is not open to doubt, so thorough is the agitation which the rags receive in the dusting machine, but on the second there appears more room for question. It is well known that chemical action between different substances takes place much less readily when they are brought together in the solid than in the liquid or gaseous form. Moreover, the emanations from the sick by which rags might be infected, are in many cases viscid fluids which, when dry, would encrust the fibres and fill up the interspaces of the fabric in such a manner as to escape both contact with the carbolic acid and the action of the dusting machine, and yet would fly off as dust when the fabric was torn by the cutter. The stiffening of new calico is not removed by passing through the dusting machine, yet if such stuff be torn asunder a cloud of dust will be seen to fly from it. It must also be borne in mind that there is a considerable difference between the direct application of disinfectants to infected

matter, and their application when such matter is scattered through a large bulk of other materials; the quantity and degree of concentration required for efficiency in the latter case cannot at all be judged of from what would be sufficient in the first case. The use of carbolic powder deserves trial, though it would be difficult to obtain positive proof of its efficacy. It is only applicable at those mills at which the rags are dusted before sorting.

3. *Disinfection by heat.*—Heat is one of the most effectual disinfectants, but its application in the present case, besides requiring expensive apparatus, has some drawbacks. Boiling, as before said, is considered by manufacturers to be inapplicable. It may, perhaps, be doubted whether the objection raised by manufacturers to any processes involving wetting the rags amounts to more than that such wetting would necessitate some expense and trouble in subsequent drying. The most valuable class of rags, *i.e.*, white rags, have been repeatedly washed, often in boiling water, before they come into the manufacturer's hands. At some mills the rags after boiling are stored wet for some weeks to soften the fibre and facilitate pulping.

Dry heat is commonly used in the disinfection of articles of clothing and bedding, and good results may be obtained if the stove be well constructed. The difficulty in the way of its application to rags would be the length of time required in order to disinfect large quantities of non-conducting materials. Unless they were loosely spread abroad, which would take much time and would necessitate a good deal of handling, the heat, in order to enable it to penetrate into the interior of the mass, must either be great or be long-continued. Experience, however, has proved that a dry heat of 250° F., a temperature sufficient to destroy all infection, can be employed without injury for the disinfection of articles of cotton and linen which have to be used, not merely as rags, but for further wear, provided that the heat chamber be such that this temperature can be maintained uniformly throughout it, and that care be taken that there are no superheated sides of the chamber with which articles can come into contact. The application of heat in the form of high-pressure steam instead of dry air would, however, have the advantages of further security against scorching, and of greatly shortening the time required for the penetration of the heat, more especially if the steam pressure be alternately relaxed and reapplied so as to displace the air remaining in the interstices of the material. From some experiments which I have made, I conclude that it is practicable, with steam at 15 lbs. pressure (= 251° F.) thus applied, to disinfect rags (unless they have been compressed by hydraulic pressure) without unpacking the bales, an important advantage both as regards saving of labour and avoidance of risk; that the texture of the rags would not be injured; that the rags would not be wetted to a serious extent by the steam; and that the cost of the process need not exceed 2*s.* 2*d.* per ton of rags, even if it were necessary to erect special apparatus for the purpose. In many paper mills the boiling of the rags is effected by steam under pressure, and the same boilers might probably serve for disinfection; the rags being submitted to the action of steam alone, without water.

II. Are there any particular classes of rags in respect of which it is desirable that precautionary measures of disinfection should be used? We may consider this question in reference to—

A. Rags from places where infectious diseases are known to be epidemic.
B. Foreign rags.
C. Hospital rags.
D. Very filthy rags.

A.—In places where infectious diseases are prevalent it is very probable that rags infected by the sick may find their way into the collector's hands negligently or unwittingly, though not often, it may be hoped, in wilful disregard of the law and of the safety of others. It is, therefore, desirable that rags known to come from such places should be disinfected prior to sorting. Before, however, the rags reach the paper manufacturer they have commonly passed through several hands, and have been sorted and re-sorted so that all knowledge of their origin is lost; except that different classes of rags are sold under local designations recognised in the trade, *e.g.*, "London seconds," "country seconds," &c., to some extent corresponding with their origin, and having distinctive characters by which a paper-maker of experience can recognise each variety.

B.—*Foreign rags.*—These differ from English rags in that they have commonly, for convenience of transport, been compressed into bales by hydraulic pressure; these bales are almost as compact and hard as those of cotton. The countries from which rags are imported comprise most parts of the civilised world, but more especially the continent of Europe and the Levant. It is probable that in many of the countries from which rags are imported there is no law to forbid infected rags becoming articles of merchandise. Hence there is a somewhat greater presumption than in the case of English rags, that infected articles may be present among them. On the other hand, the length of time that must elapse between their collection and their coming into the hands of the manufacturers is doubtless greater in the case of imported rags than in those of home origin, and the potency of any virus which they might contain may be thereby diminished. There is no evidence to show that foreign rags are more liable to transmit infection than English rags of a similar class. In the St. Mary Cray outbreak, in which at first blame was attributed to certain foreign rags, later inquiries showed that the rags in question had been in use for many months before the outbreak occurred, and that many of those who were attacked with small-pox had not been working on them. Of the other cases before alluded to in this report, in only three, viz., those at East Malling, at Creech, near Taunton, and at Woodside, near Aberdeen, was the mischief attributed to foreign rags; moreover, in the Creech case the rags were only in part foreign, and in the Woodside case the manufacturers stated that the rags which had been from time to time suspected to be the source of the infection came from England and Scotland and not from the Continent. Of the cases appended to Dr. Bristowe's report, in only two was blame attributed to foreign rags; it is also stated by Dr. Bristowe that in the Lancashire mills, where many Turkey and Egyptian rags (which are commonly very filthy) are used, diseases peculiar to those countries have never been introduced by their agency. The Belgian experience, as before mentioned, is similar. It does not appear, therefore, that any strong case can be shown why foreign rags more than home rags should be subjected to a disinfecting process.

There appears to be an impression that foreign rags are disinfected before importation, but so far as I have been able to ascertain, in the cases where any process of disinfection of rags is carried out, it is practised rather with a view of preventing the importation of disease by their means than for the security of foreign countries, and can only be a safeguard to the latter in the case of rags passing through from port to port.

In the maritime regulations, as to plague, of the Egyptian General Board of Health, appended to Mr. Netten Radcliffe's Report on Quarantine in the Red Sea (Supplement to Ninth Annual Report of the

Local Government Board), Article XIV. prescribes that disinfection of susceptible objects, among which rags are included, shall be rigorously carried out.

The French Imperial Decree of May 27, 1853, in accordance with the International Sanitary Convention, classes rags in the first or most susceptible of the three classes in which, for the purpose of the application of sanitary measures, the various kinds of merchandise are by Art. 62 arranged. In case of suspected plague, articles of this class are to be unloaded and subjected to purifications consisting of the opening of the bales and the free exposure of the contents to the air. Merchandise of this class arriving from countries suspected of yellow fever, if no cases have occurred on board during a voyage of more than ten days' duration, is to be subjected to a simple aëration without unloading. In the case of cholera no particular sanitary measure is prescribed.

A decree, dated March 15, 1879, compels all rags imported into France by sea to be disinfected, and the importation of rags is restricted to certain ports where disinfecting apparatus have been provided. In order to evade this requirement it has been the practice to unload cargoes of rags at neighbouring ports in other countries and carry them into France by land. M. Gibert (loc. cit.) consequently recommends that the importation of rags by land be restricted to certain frontier towns where facilities for disinfection exist, and that all rags be disinfected before leaving or even entering the warehouses, and be not allowed to remain on the quays. Also that disinfecting apparatus be provided in all towns of 10,000 inhabitants.

M. Van de Velde (loc. cit.) differs from these conclusions, considering that the compulsory disinfection of all imported rags would be an impracticable and unnecessary interference with trade, and recommends rather that infected articles should be disinfected at their place of origin, as the law in England requires. It would seem that neither in France nor Belgium does the law forbid the selling or exposure without previous disinfection of infected clothing or rags. In Holland the law is similar to that in England, and in Turkey disinfection of some kind is said to be applied to articles suspected of being infected.

Dr. Bristowe states that sulphur and lime are occasionally found sprinkled among foreign rags, in the opinion of some of his informants for the purpose of disinfection, in that of others solely to increase weight; Messrs. Joynson's manager tells me that they occasionally find among foreign rags a gritty powder evidently added with the latter object.

C.—*Rags from hospitals or which have evidently been used by the sick.*—Poultices and bandages are stated to be occasionally found in all rags. Such applications, however, as before remarked, are not of ordinary use in the treatment of the eruptive fevers, though they might be sometimes required if local complications should arise in the course of the disease. Their presence in a notable proportion in a sample of rags would point rather to their having been used for surgical cases, which are not, in English hospitals at least, treated along with infectious cases. The virus of phlegmonous erysipelas would be that most likely to be present in poultices or soiled bandages, but we have at present no evidence of danger having arisen on this score.

"Institution rags," including rags from hospitals, form in the trade a distinct class, for which some paper-makers have a preference, because such rags are comparatively new. It may be taken for granted that the authorities of English hospitals in which infectious diseases are treated would take care that no infected rags from them should come into the market; whether the same could be said of hospitals in other countries

I cannot say. Doubtless the greater number of infected rags which pass into circulation come from private households, especially of the poorer class.

D.—*Rags exceptionally filthy.*—Rags which are obviously filthy may be regarded, according to Mr. Allen, as more likely to have infectious properties than cleaner qualities, for the reason that the former proceed from a dirty and negligent class of people, whereas in decent households infected rags are more commonly destroyed, their dangerous properties being recognised. In some paper mills, at least, the cutters are allowed to reject any offensive rag to the handling of which they may object.

A priori it would seem likely that dirty white rags, forming, as they do, articles in intimate contact with the body, as underclothing, sheets, handkerchiefs, &c., would be more likely to be infected than coloured articles, and this view is borne out by the fact that almost all of the outbreaks of disease mentioned in this report have occurred at mills at which fine writing papers are made, in the manufacture of which white rags are used.

The question has been suggested, Can anything be done by paper-makers in their dealings with rag merchants to hinder the transmission of rags of presumably dangerous quality, *e.g.*, a money forfeiture in case of filthy matters being found among rags by sorters? No doubt, if the rags were not, as regards cleanliness, of the specified quality, or according to sample, the paper-maker would have his legal remedy against the rag-merchant. Filthiness of rags is disadvantageous to the paper manufacturer, involving greater trouble in cleaning them. In the eyes of the trade, however, filthiness would not be a reason for rejecting rags altogether, but for sorting them into an inferior class consisting normally of dirty rags. A manufacturer would no doubt complain if he found many filthy pieces in a parcel sold him as fine white rags, but he could hardly do so if the parcel were purchased as of a low quality.

If manufacturers declined to receive filthy rags the dealers would either have to reject them, or to cleanse them before sale; this would, of course, increase the price, but the rags would presumably be worth more to the paper-maker if they were clean, and the cleansing would increase the comfort and security of the paper-mill operatives; on the other hand, however, it would necessitate more handling of the rags while they were in the hands of the rag merchant, or collector.

III.—Should measures of precaution against rag-infection be made compulsory, and if so, upon whom?

In answering this question it has to be borne in mind:—

1st. That, apart from a knowledge of their history, there are no characters or means by which it may be known that a given sample of rags has, or has probably, been exposed to infection.

2nd. That section 126 of the Public Health Act, 1875 already imposes a penalty on any person who "gives, lends, sells, transmits, or "exposes without previous disinfection any bedding, clothing, rags, or "other things which have been exposed to infection from any dangerous "infectious disorder."

If this law were universally observed the question of rag-infection would hardly arise, at any rate as regards rags of home origin. If infected rags pass into the hands of dealers it is not because the law is not sufficiently stringent, but because of the practical difficulties in the way of its enforcement. In this matter we must look for increased care and regard for the safety of others with the improvement of education. It is not evident that any amendment of the law could be made which would better ensure the object in view. Obviously it is the

person who first sells the rags who should be responsible for their freedom from infectious properties, both because he alone is likely to know their history, and because if disinfection were postponed to a later stage, the rags would pass through several hands while still retaining their infectious properties. The section bears primarily upon the original possessor of the rags, but would apply to any person into whose hands they might afterwards pass who knew of their infectious character. The difficulty would of course be to prove such knowledge.

The responsibility being thus thrown upon the original possessors of the rags it would hardly seem fair to compel the marine store dealer, rag merchant, or paper manufacturer into whose hands they might subsequently come, to atone for the omissions of the first vendor by a process of disinfection applied indiscriminately to all rags, while as regards enforcing disinfection of particular classes of rags it would be very difficult to draw a line between the cases in which it was required and those in which it might safely be omitted. By whomsoever the disinfecting process had to be carried out, its effect would ultimately be to increase the costs of rags to the paper maker, and to this in the present circumstances of the trade much objection would probably be raised. It is stated by manufacturers that at the present time the paper trade is suffering severe depression, partly from over-production, but to a great extent from foreign competition and foreign tariffs, so that any process calculated to increase the cost of the raw material would add to their difficulties, and place them at a disadvantage in regard to their foreign competitors.

Possibly in time of an epidemic it might be desirable that all rag collectors and marine store dealers should be compelled to disinfect each day by sulphur fumigation or otherwise the day's gatherings; but having regard to the class of persons employed in this branch of the trade, it would be very difficult to ensure that this should be properly carried out. It would also be desirable that such rags as were foul should be cleansed before they left the collector's hands. This matter paper makers and rag merchants probably have in their own hands by refusing to buy filthy rags, or rejecting such as may be found in the parcels sent them.

These remarks hardly apply to the case of foreign rags. Any system of quarantine like that practised abroad in the case of rags from plague-stricken countries would be opposed to the sanitary policy of this country, and would be the more inapplicable since the diseases which have to be guarded against are already indigenous among us. Moreover, experience has not shown that foreign rags are more liable than others to cause disease.

It would nevertheless be gratifying if paper manufacturers, for the protection of their workpeople, could see their way to the adoption of some effective means of disinfection of rags. Of the processes which have been proposed to this end, that by high-pressure steam seems to promise most.

Recapitulation.

The following conclusions are arrived at:—

1st. That cases of infection by means of rags do occasionally occur, although, comparatively speaking, not very frequently.

2nd. That small-pox is the disease most likely to be thus conveyed.

3rd. That all rag workers should be vaccinated and re-vaccinated.

4th. That dust should be avoided. The preliminary dusting of the rags before sorting is to be recommended, but the dust should not be allowed to contaminate the air of the workroom.

5th. That certain measures of disinfection are available, among which exposure to air, fumigation with sulphurous acid, and exposure to hot air or high-pressure steam may be mentioned, each of which has its advantages and drawbacks under certain circumstances.

6th. That in the absence of means by which it may be known whether or not rags have been infected, the cases in which disinfection would appear especially desirable are (*a*) rags from places where epidemics are known to exist; (*b*) rags in a filthy state; and perhaps (*c*) foreign rags, especially if coming within the two previous categories.

7th. That under existing circumstances it is not advisable that any obligation as to disinfection of rags, other than that already imposed by section 126 of the Public Health Act, 1875, should be imposed upon persons engaged in the rag trade.

November 1881.

APPENDED NOTES.

Case A.

Sir, Whitefriars, Settle, June 28th, 1881.

In accordance with sub-section 15, Art. 18, of the General Order of the Local Government Board of March 11th, 1880, I have to report the occurrence of a case of small-pox at Goose-Eye in the Oakworth Urban Sanitary District.

The case was reported to me upon the 9th of June by the medical attendant, who had seen it for the first time upon the 6th, and had the case removed upon the 7th into the infectious wards of the Workhouse Infirmary at Keighley.

I visited Goose-Eye upon the 9th of June, and found that the patient (a young woman of 21 years of age) had been working up to the time of her illness as a rag sorter in a paper-mill (Turkey Mill) close to their house at Goose-Eye. Neither she nor any member of the family had been away from home for some time previously.

The case was one of well-marked small-pox, the rash being fully developed all over the body, but not confluent. She had been in a poor state of health for some time past. Upon examination there were no signs of vaccination to be found, although her mother affirmed that she had been vaccinated when a child.

I visited Turkey Mill, and found that 25 other women (their ages ranging from 18 to 60 years) were engaged in rag sorting. Of these one young girl had no vaccination marks upon her, and another only one indifferent mark.

I also found that the rags, which are of the finer sort (being intended only for the manufacture of writing papers), and which not unfrequently contain poultices and dressings, and are imported from all parts of this country, as well as from France, Italy and Russia, do not undergo any process of disinfection, such as stoving or boiling, before they are put into the hands of the workpeople. The walls and floor of the rag-sorting room are covered with dust from the rags. A cargo had recently been received containing rags from Halifax, but the sorting of these had not been begun before the girl's illness.

She had, I was informed, for a month previous to the attack, been engaged in sorting clean stuffs of the best quality in use.

I can attribute the outbreak to no more definite cause than the suspicion of infection conveyed in the rags.

The premises where the patient was living have been thoroughly disinfected and cleansed, and the children re-vaccinated. Three weeks have now elapsed since the case was removed to the hospital, and there has been no further appearance of the disease.

I am, &c.

(Signed) Francis E. Atkinson,
L.R.C.P. Lond., M.R.C.S.

I visited the above case on June 11th with Mr. Atkinson, and can confirm his account. The Turkey Mills are situated in a retired valley three miles above Keighley. A road runs through the valley by which it is stated that in summer time many tramps come on their way from Lancashire to Yorkshire across the moors, passing the mill and the patient's home, the kitchen of which serves also as a small shop. Tramps are the only means other than the rags by which it seems at all likely that infection might have been brought, and there is no reason to think that it was so. Both the District Medical Officer and the Medical Officer of Health for Keighley state that the town and neighbourhood had been for some time free from small-pox. At the Turkey Mills the processes differ from those at the St. Mary Cray Mills in certain respects. There is no preliminary dusting. The rags are sorted and the buttons, &c. removed by women. The cutting, instead of by hand, is done by a machine with revolving blades like a chaff cutter. The pieces after cutting are "willowed" and dusted in a machine standing in a corner of the rag room, from which much dust proceeds. It is proposed to put up a fan to withdraw this dust better. The rags are next boiled with caustic soda in upright fixed boilers by steam at a pressure of 20 lbs. or upwards. They are torn up by machinery, as they revolve in an elliptic tank, being washed at the same time. The shreddy mass is next pressed in a hydraulic press. It is then bleached with solution of chloride of lime and again pressed. It now forms cakes of white fibrous pulp resembling cream cheese in appearance, and termed "half stuff," in which state it is put by for use as required in the operations of paper-making proper.

H. F. P.

Case B.

On June 16th, 1881, Mr. James Williams, Medical Officer of Health to the Holywell Rural Sanitary Authority, reported to that authority the occurrence of a case of small-pox in a girl employed in cutting rags at the Afonwen Paper Mills. In the absence of all other discoverable sources of infection he concluded that the patient had received the disease through the medium of the rags which she was engaged in cutting. In communicating a copy of this report to the Local Government Board the Sanitary Authority expressed their opinion that all foreign rags should be disinfected on disembarkation, and home rags likewise previously to their transit from place to place.

I visited the Afonwen paper-mills on August 12th, 1881, with Mr. Williams.

The patient E. J., æt. 15, had been vaccinated in infancy, but had only one faint scar. She had only been working at the mill for three weeks before her attack, having previously been in service at an inn in Caerwys, a small neighbouring village. She had not been farther away for a long time, and no small-pox was known to have previously existed in the district.

The Afonwen mills, at which the finer qualities of writing paper are manufactured, are situated in a valley far from any town. The workpeople

reside in the neighbourhood, mostly in Caerwys. At the time of the occurrence of small-pox 70 hands were employed, of whom 18 were rag-cutters. The rags upon which they were employed were "best whites," British white rags of the cleanest class, but not new. They had been recently purchased of rag merchants of repute in Manchester, and nothing unusual was observed about the sample. Foreign rags are never used at the Afonwen mill. The rags are "willowed" before cutting, but in a separate room, so that the rag-cutters are not much exposed to the inhalation of dust.

The oldest hands at the mill do not remember any other cases of small-pox to have occurred there.

Shortly afterwards I received information from Mr. Williams that a case of small-pox had recently occurred among rag-cutters at the Greenfield paper-mills, near Holywell. I visited the spot with him on Aug. 29th. Unlike the other mills at which small-pox has occurred, the Greenfield mills manufacture printing paper, and the cheaper qualities of writing paper, the materials used being esparto grass with a twentieth part of rags or waste thread. The latter material consists of ravellings of thread from linen factories: having never formed part of any garment, it is not likely to be a vehicle for infection. The rags, which are of the class known as "seconds," are obtained partly from local collectors; partly are foreign. All the English rags used are said to be from neighbouring towns. They were not known to have come from places where small-pox had been prevalent. Some are said to have been very dirty. The rags do not undergo any preliminary dusting. The cutting room is well-ventilated, and not particularly dusty. The mill employs 100 hands, of whom only nine are cutters. One of these, Sarah J., æt. 17, was taken ill about the middle of August with modified small-pox. She had been vaccinated in infancy, and bore one large mark. (Of the other cutters, five had been vaccinated in infancy, two had had small-pox in infancy, and one was said to have been vaccinated, but had no mark.) S. J. had cut both rags and thread; but for a fortnight, ending about a week before her illness, she had cut rags only. She had not been away from home before her illness, and no history of infection could be ascertained. She lived, however, in a small and overcrowded house, in a populous, poor, and squalid neighbourhood, and close to a much frequented main road. She had, therefore, more opportunities of coming unwittingly in contact with small-pox than some of the other cases referred to in this report, and the probability of the infection having been received through rags is proportionately weakened. There does not appear to have been any communication between this case and that at Caerwys, and the two outbreaks, which occurred at places six miles apart, must, I think, be looked upon as quite distinct and unconnected.

H. F. P.

Case C.

In this case the patient, a girl æt. 14, residing at Shaftesbury, said to have been vaccinated in infancy, but on whom no marks were found, was engaged in sorting rags of all kinds. Her employer was a middleman, living at Shaftesbury, who bought rags from collectors in the neighbouring towns and villages, and sold them to merchants and paper manufacturers. The evidence in this case connecting the outbreak of small-pox with rag infection was not clear. The patient denied having been away from Shaftesbury, but it was found that her statements were not to be depended on, for she had been not long before her illness to see a relative some miles off, and had had a dress given her which might have come from London. Small-pox had existed in two places within the area from which the dealer obtained rags, but it appeared that none from those places had come into his possession at dates which would account for the outbreak.

H. F. P.

App. A. No. 15.

On an outbreak of Small-pox among Rag-sorters; by Dr. Parsons.

Case D.

Extract from a Report to the Local Board on the Outbreaks of Small-pox in Maidstone, 1881. By M. A. Adams, F.R.C.S., Medical Officer of Health.

The first case I shall call your attention to was that of a girl named Maslin, who worked at Springfield Paper Mill. She came out in the rash of small-pox on the 18th of April, and on the 19th, or next day, four other mill girls came out in the rash, on the 20th two others, and one on the 21st.

All these eight girls were working in the same room as rag-cutters. On the 25th two more women, and on the 26th one other were taken, but these came from a different room.

The place from whence the first batch of cases arose, is the upper sorting room, where the rags are cut and sorted; the second batch came from the overlooking room, where the rags are taken to after leaving the first or sorting room.

Now all these 11 cases occurred within the period of incubation, therefore the sufferers could not have taken the disease one from another, and it is clear that those in the sorting room were exposed to the infection some few days before those in the overlooking room. It is also quite beyond the bounds of reason to doubt that the infection, come from whence it might, was disseminated from the mill as a focus.

* * * * *

MILL.			MILL.		
No.	Date of		No.	Date of	
	Sickness.	Rash.		Sickness.	Rash.
	1881.	1881.		1881.	1881.
1	April 15	April 18	18	May 5	May 7
2	„ 16	„ 19	19	„ 6	„ 8
3	„ 16	„ 19	20	„ 6	„ 8
4	„ 17	„ 19	21	„ 8	„ 10
5	„ 17	„ 20	22	„ 8	„ 11
6	„ 18	„ 19	23	„ 8	„ 11
7	„ 18	„ 20	24	„ 11	„ 13
8	„ 19	„ 21	25	„ 13	„ 14
9	„ 22	„ 25	26	„ 17	„ 20
10	„ 23	„ 25	27	„ 18	„ 19
11	„ 23	„ 25	28	„ 23	„ 25
12	„ 24	„ 26	29	„ 26	„ 28
13	May 1	May 3	30	June 3	June 5
14	„ 1	„ 3	31	„ 5	„ 7
15	„ 2	„ 4	32	„ 14	„ 17
16	„ 4	„ 5	33	„ 24	„ 26
17	„ 4	„ 5	34	July 27	July 30

To account for these cases we must suppose either a person or thing infected by small-pox to have been in the sorting room on the 1st or 2nd of April. If a person, he or she could be traced; and to leave no doubt in the matter, I myself personally visited every absentee from work from that mill room. Referring back to what has been said of the Banyard, Obee, and the two other early cases, it hardly needs my assurance that neither of these persons nor their attendants had been near the sorting room on those April days, nor indeed at any other recent time so far as I know, nor had any clothing or other articles belonging to them been there either; and if they or their belongings had not been actually in the mill room, we are cast upon a last and more ridiculously improbable conjecture, that one of them had directly or indirectly visited each of the mill hands at her home on one and the same day, curiously enough selecting the mill hands alone for victims from out of the general inhabitants of those homes, and only those, too, who worked in the upper sorting and overlooking rooms: the notion is of course altogether too absurd.

How then could the mill outbreak have originated? If not from a person, the infection must have emanated from a thing, and if so what thing?

The answer to this question is hardly left in doubt when it is remembered that the second batch of mill cases broke out in the overlooking room about a week later than the first batch which had come from the sorting room; the rags, recollect as already pointed out, passing in the ordinary way of business from the sorting to the overlooking room.

Imagine a parcel of infected rags to have found its way into the sorting room on or about the 1st of April, and the chain of events is perfect: on no other hypothesis, so far as I can see, can the facts of the case be reconciled.

Allow me here, once for all, emphatically to say that no direct or implied blame is intended to be cast upon the proprietors, officers, or others connected with the mill. Rags may be of the whitest and most cleanly description and yet hold the most deadly infection. Fault, if fault there was, lay with those who originally collected and made merchandise of the infected rags.

I have heard of, and can readily believe, reckless conduct such as the following:—Undertakers do, and often are instructed to remove with a corpse all bed and body linen, especially when death has arisen from infectious disease. It might easily happen for small-pox unsuspectedly to be spread broadest through the medium of a sheet, a shirt, or a pillow-case, though such article might to the eye be clean and wholesome.

From these 11 original mill cases others sprang, making a total of 34; some directly, others in a very roundabout way. Thus No. 15 worked at the same hurdle as No, 5 had worked, and a fortnight later she took the disease; and again, No. 22, also working at the same hurdle, sickened a few days later. No. 7 had an associate, No. 10, who worked at Turkey Mill; these two were constantly together, and No. 10 took the disease of No. 7, and what is more, gave it to a fellow workwoman at Turkey Mill, and thus it travelled to three others at Turkey Mill, besides the mother, brother, and sister of the primary case.

In answer to my inquiries Mr. Adams states that the women first attacked had all been working on and before April 1st on the same class of rags, viz., white English rags from London merchants. There was nothing to lead to the suspicion that these rags had come from filthy sources. There is no treatment with a view to the prevention of risk of infection, and the dusting is done in the overlooking room.

H. F. P.

No. 16.

App. A. No. 16.

Official Memorandum as to Trichinous Disease and Cooking of Meat.

Memorandum as to Trichinous Disease and Cooking of Meat.

Some very serious diseases in man, of which the chief is named Trichiniasis, result from eating the flesh of pigs that have become infested with minute parasitic worms.

It is upon the imported flesh of foreign pigs that suspicion of being thus infested has recently fallen; but it will be prudent to regard all pigs as liable to parasitic disease, and to remember that the influence of it upon the animal is not nearly so evident as when the disease attacks man.

Inasmuch as the meat infested with these worms cannot be recognised by any popular test, and the worms themselves can only be detected by careful microscopic examination, it becomes important to take precautions against harm to man in the case of meat from all pigs.

The only known means of avoiding disease in man from this dangerous quality of meat from pigs, is by very thorough and efficient cooking. If there is reason for thinking a particular sample of meat to contain the parasites, it ought not, on any account, to be eaten, no matter how it is cooked.

Hams, sausages, and like articles, whether or not they have been smoked or salted, should never be eaten in the raw state.

To be efficient for the required purpose, the cooking of pork, of hams, of bacon, and of other articles should be prolonged for about half as much time again as is customary. The smallest joint should be cooked for not less than an hour; and whatever be the size of the joint, it should have not less than half an hour's cooking for each pound of meat. No part of a joint that is seen to have an underdone portion in it should be eaten.

In boiling hams and pork, the meat should be put into cold or lukewarm water; and the period of cooking should be reckoned from the time when the water boils.

In boiling several joints of pork or several hams (as required at institutions and elsewhere), they should not be put together, in bulk, at the same time into the same cooking vessel. Each joint should be put into a separate vessel, and boiled with a good quantity of water.

Though the caution is not given for the avoidance of the particular diseases here in question, the present is a useful opportunity to mention that it is of much importance to health to see that larders, and places where cooked meat is stored, are kept always clean and free from the chance of foul air entering them. Serious outbreaks of disease are appearing with some probability to be related to neglect of this precaution.

Local Government Board,
February 28th, 1881.

APPENDIX B.

No. 1.

On the Results of Examination of certain Samples of Water purposely polluted with Excrements from Enteric Fever Patients, and with other Matters, by Dr. Cory.

The following inquiry was undertaken mainly to ascertain how far some of the processes in common use among chemists, for the analysis of water, could be relied upon to detect dangerous pollutions. To this end typhoid stool was in the first place used as the polluting material, and afterwards healthy stool, urine, blood serum, and other materials have been employed. Opportunity, however, was taken of making further application of the analysis, so that other questions, more or less akin to the inquiry, have been in some measure considered. These secondary intentions have necessarily been imperfectly fulfilled. They must be looked upon sometimes as preliminary to more extended inquiry, sometimes as merely tending to throw light upon other results.

Experiment I.

A consistent typhoid stool was obtained on the 3rd of February 1880, from a patient, William B., aged 26, who was admitted into St. Thomas's Hospital on the 13th of January. His temperature on the morning of the 4th of February was 38°·3 C. (101° F.). He was taking milk, beef tea, and an effervescing mixture of citrate of potash.

One gramme of the stool was thoroughly mixed in a small mortar with 100 cubic centimetres of the Lambeth Company's water, drawn from a tap in connexion with a cistern at 14, Palace Road. Ten cubic centimetres of this mixture was put into a bottle, labelled C, containing two litres of the water. To another bottle, labelled B, containing the same quantity of water, 5 c.c. of the same mixture were added, and a third bottle, labelled A, was filled with unpolluted water. These three samples C, B, and A, were sent to Dr. Dupré for analysis on February 3rd, 1880.

Another bottle, containing the same ingredients in the same proportions as C, and also labelled C, was sent to Mr. Stewart for microscopical examination on the 4th of February 1880.

Both Dr. Dupré and Mr. Stewart were acquainted with the amount and nature of the pollution in the bottles submitted to them.

App. B. No. 1.

On Samples of Water purposely polluted with Excrements, etc.; by Dr. Cory.

The following are the results of their examinations:—

The stool used was that of Wm. Bennett, obtained on the morning of the 3rd of Feb.	A. Unpolluted water drawn on the 3rd Feb.	B. 2005 c.c. of water polluted with ·05 grm. of typhoid stool. Water drawn on 3rd of Feb. Pollution = 1·75 grains of stool per gallon.	C. 2010 c.c. of water polluted with ·1 grm. of typhoid stool. Water drawn on 3rd of Feb. Pollution = 3·5 grains of stool per gallon.
Appearance	Clear	Very slightly turbid	Slightly turbid.
Colour	Pale greenish	Pale greenish brown	Pale brown.
Deposit	None	Minute trace	Trace.
Nitrous acid	None	None	None.
Phosphoric acid	Very minute trace	Strong trace	Much.
Colour of residue	Very pale yellowish brown.	Very pale yellow brown.	Pale yellow brown.
Behaviour of residue on ignition.	Blackens very slightly	Blackens very slightly	Blackens markedly.
	Grains per gallon.		
Oxygen absorbed from permanganate (cold).	0·0455	0·0490	0·0525
Total dry residue	24·06	24·06	24·36
Volatile matters	0·84	1·96	1·96
Fixed salts	23·24	22·12	22·40
Chlorine	1·05	1·05	1·05
Nitric acid	0·77	0·77	0·77
Free ammonia	0·0021	0·0025	0·0027
Alb. ammonia	0·0075	0·0095	0·0123

The waters were allowed to stand at rest for 24 hours, and only the clear water (without the deposit) was taken for analysis.

[Mr. Stewart's Report on the Examination of a Bottle of Water similar to C., February 7th, 1880.

Deposit fairly abundant.

It consisted chiefly of crowds of flagellate infusoria (*a*, *b*) (*see* accompanying Plate, fig. 1), some with collars (*c*), a few ciliate infusoria (*d*). Bacterium termo and lineola both active and resting (*e*), in considerable quantity; motionless, many-jointed curved filaments of schizomycetous fungus (*f*), and living mycelium (*g*); a few dead diatoms, synedra (*h*); fibres of textile fabrics, *e.g.*, stained wool and flax; amorphous organic matter.]

It will be noticed in Dr. Dupré's analysis of B that 1·75 grains of typhoid stool per gallon added nothing perceptibly to the weight of the total dry residue.

Sub-Experiment.

It was felt, therefore, desirable to ascertain, firstly, the weight of solid dry residue contained in a given weight of an ordinary typhoid stool; and, secondly, the amount of solid dry residue of the soluble portions of a given weight of an ordinary typhoid stool. The latter determination was undertaken, because only the clear water in the samples was taken for chemical analysis.

A stool of this description was accordingly procured from a case of typhoid (William Cox), in St. Thomas's Hospital, on March 6th.

In order to ascertain the amount of solid dry residue in a given weight of the stool, 2·05 grms. were placed in a watch glass over a dish of sulphuric acid under a bell glass, the air being then exhausted from bell glass. In 24 hours the fæces were desiccated and weighed only 0·17 grm. The proportion, therefore, of solid dry matter contained in the fæces, determined in this manner, was as ·083 : 1.

To determine the second point. One gramme of the same typhoid stool (which, if dried, would have weighed ·083 grm.) was mixed with

Figure 1.

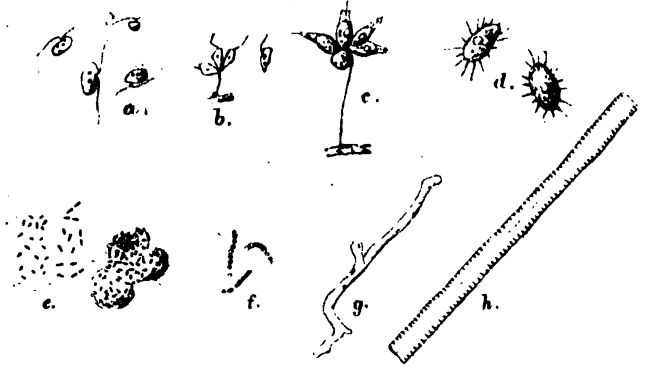


Figure 2.

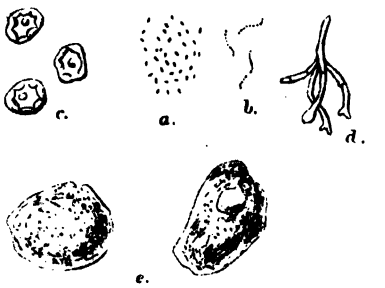


Figure 3.

Figure 4.

Dancerfield Lith 22. Bedford St Covent Garden.

100 c.c. of distilled water, and the mixture allowed to stand for 24 hours. It was then filtered through a filter paper. This being done, the residue with the filter paper was placed under a bell glass to dry over sulphuric acid. Another clean filter paper which had previously been ascertained to weigh the same as the one which was used, was also placed under the bell glass in order that both filter papers might dry together under similar circumstances. In weighing, the clean filter paper was placed in the opposite scale of the balance and the residue was then found to weigh ·022 grm. If this weight, therefore, be subtracted from the weight of the total dry residue we get ·083 — ·022 = ·061 grm. as the weight of the soluble portions in 1 grm. of the stool.

Experiment II.

A consistent typhoid stool was obtained on the morning of the 10th of February from Harriet M., aged 18, who was admitted into St. Thomas's Hospital on the 29th January 1880. On the morning the stool was obtained, typhoid spots existed on her abdomen. She was taking milk only as diet, and xx minims of liq. ammon. acet. as medicine.

One gramme of the stool was weighed in a watch glass and thoroughly mixed with 100 c.c. of water, drawn from the tap at 14, Palace Road, on the 10th February 1880.

Ten c.c. of this liquid were mixed with 2 litres of the water, and the bottle containing the mixture was labelled E. Another bottle, labelled F, was prepared by adding 15 c.c. of the liquid to 2 litres of the water, and a third bottle, D, was filled with unpolluted water.

The above samples were submitted to Dr. Dupré for chemical analysis on the 11th February 1880. He was acquainted with the nature, but *not* the amounts of pollution in the samples.

The results of his analyses are given in the following table :—

The stool used was from Harriet Mills, obtained on morning of the 10th of Feb.	D. Unpolluted water drawn on the 10th Feb. 1880.	E. 2010 c.c. of water polluted with ·1 grm. of typhoid stool. Water drawn on the 10th Feb. 1880. Pollution = 3·5 grains of typhoid stool per gallon.	F. 2015 c.c. of water polluted with 15 grm. of typhoid stool. Water drawn on 10th Feb. 1880. Pollution = 5·21 grains per gallon.
Appearance	Clear	Slightly turbid	Slightly turbid.
Colour	Greenish yellow	Pale brownish	Pale brownish.
Deposit	None	Trace	Strong trace.
Nitrous acid	None	None	None.
Phosphoric acid	Trace	Much	Very much.
Colour of residue	Slightly brownish yellow.	Slight brownish yellow.	Slight brownish yellow.
Behaviour of residue on ignition.	Blackens very slightly.	Blackens markedly	Blackens markedly.
	Grains per gallon.		
Oxygen absorbed from permanganate (warm).	0·1095	0·2576	0·2736
Total dry residue	23·40	22·68	23·80
Volatile matters	1·68	2·80	2·52
Fixed salts	20·72	19·88	21·28
Chlorine	1·05	1·05	1·05
Nitric acid	0·77	0·77	0·77
Free ammonia	0·0005	0·0026	0·0014
Alb. ammonia	0·0056	0·0101	0·0140

[Mr. Stewart's examination of the mixture of typhoid stool and water used to pollute samples E and F.

Contained numerous bacteria (*a*) (*see* Plate, fig. 2), a few vibrios (*b*). Some unknown bodies possibly altered food (*c*), growing mycelium (*d*),

and many dark orange-brown granular masses of irregular form but similar size (*e*).]

The three samples, D, E, and F, taken in conjunction with those of the first experiment, offer an opportunity of judging how far the "albuminoid ammonia" process of Messrs. Wanklyn and Chapman will indicate quantitively, pollutions with typhoid stool when the stool is added to two waters of different degrees of impurity, the amount of original impurity in each water being known.

If we deduct the amounts of the ammonia and albuminoid ammonia found in the two unpolluted samples A and D from the amounts of the ammonia and albuminoid ammonia found in the polluted samples B and C, and E and F, respectively, we arrive at the results given in the table below.

The quantities are given as before in grains per gallon.

Chemical indications afforded by pollution with	William B.'s typhoid stool.		Harriet M.'s typhoid stool.	
	(B.) 1·75 grains per gallon.	(C.) 3·5 grains per gallon.	(E.) 3·5 grains per gallon.	(F.) 5·21 grains per gallon.
Free ammonia -	·0004	·0006	·0021	·0009
Alb. ammonia -	·0020	·0048	·0045	·0064

The results are thus seen to be fairly consistent with the proportional amounts of pollution, except in the case of the free ammonia in E, which is much higher than was to have been expected.

Experiment III.

On the 17th of February a semi-solid stool was obtained from Joshua B., aged 25, who was admitted into St. Thomas's Hospital on the 12th February 1880, with typhoid fever. His diet consisted of milk only. He was taking 20 minims of dilute hydrochloric acid as medicine.

One gramme of the stool was thoroughly mixed in a mortar with 100 c.c. of the Lambeth Company's water, drawn on the 18th February. This was allowed to stand five hours, and it was then filtered through filter paper. Ten c.c. of this filtrate which was clear, but contained numerous bacteria, were added to two litres of the water, and the bottle containing the mixture was labelled H; other 12·5 c.c. of the filtrate were added to 2 litres of the water in another bottle, labelled I; a third bottle, labelled J, contained 25 c.c. of this filtrate and 2 litres of the water; and a fourth bottle, labelled G, was filled with the unpolluted water. H, I, and J were sent to Dr. Dupré for analysis on the afternoon of the 18th, whereas G was not sent until the 23rd February, which was after the results of the analyses of H, I, and J had been received. A bottle with similar contents to that above labelled H, was sent to Mr. Stewart on the 19th February.

Neither Dr. Dupré nor Mr. Stewart was acquainted with the nature or the proportion of the pollution.

	G.	H.	I.	J.
The stool used was from Joshua B., obtained on the morning of the 17th of Feb.	Unpolluted water, drawn on the 18th of Feb. Sent for analysis on the 23rd of Feb.	2010 c.c. of water polluted with 10 c.c. of filtrate from 1· grm. of typhoid stool in 100 c.c. of water. Sent for analysis on the 18th of Feb. Pollution=about ·209 grain of dried soluble matter per gallon.	2012·5 c.c. of water polluted with 12·5 c.c. of filtrate from 1· grm. of typhoid stool in 100 c.c. of water. Sent for analysis on 18th Feb. Pollution = about ·258 grain of dried soluble matter per gallon.	2025 c.c. of water polluted with 25 c.c. of filtrate from 1· grm. of typhoid stool in 100 c.c. of water. Sent for analysis on 18th Feb. Pollution = about ·518 grain of dried soluble matter per gallon.
Appearance	Clear	Clear	Clear	Clear.
Colour	Brownish green	Brownish	Brownish	Brownish.
Deposit	None	None	None	None.
Nitrous acid	None	None	None	None.
Phosphoric acid	Slight trace	Trace	Strong trace	Strong trace.
Colour of residue	Brownish	Brownish	Brownish	Brownish.
Behaviour of residue on ignition.	Blackens very slightly.	Blackens perceptibly.	Blackens strongly.	Blackens strongly.
	Grains per gallon.			
Oxygen absorbed from permanganate.	0·1284	0·2254	0·2962	0·3220
Total dry residue	23·24	23·52	23·52	23·52
Volatile matters	1·68	3·64	3·08	3·08
Fixed salts	21·56	19·88	20·44	20·44
Chlorine	1·085	1·12	1·155	1·155
Nitric acid	0·63	0·70	0·70	0·63
Free ammonia	0·0016	0·0049	0·0048	0·0084
Alb. ammonia	0·0064	0·0085	0·0084	0·0202

[Mr. Stewart's Examination of a Sample similar to H, and of the Filtrate with which H, I, and J were polluted.

Sample H, examined February 18th.

Hardly any deposit.

A few small monads (*a*), (*see* Plate, fig. 3) and some rod-like irregularly jointed short filaments of a fungus (*b*).

The filtrate with which H, I, and J were polluted, examined February 20th.

Numerous flagellate infusoria-monads (*a*), (*see* Plate, fig. 4).

Some young ciliate infusoria-paramecium (*b*).

Some round bodies which showed slight oscillatory motion, and were probably a resting condition of an infusorian (*c*).

Crowds of bacteria with some vibrios and spirillum (*d*).]

One intention of the foregoing experiment was to deprive the chemist of an obvious means of estimating the amount of pollution, viz., that of observing the relative amount of deposit in the different samples; and this was achieved, for it will be noticed that in the four analyses the appearances on inspection are described in almost identical terms.

The analysis of the unpolluted water G was postponed, because it was thought that from the analyses of H, I, and J it ought to have been possible to predict the analysis of G. This, however, was found impracticable. Thus with regard to the albuminoid ammonia, J which was polluted with 25 c.c. of the filtrate, contained more than twice as much albuminoid ammonia as I, which was polluted with 12·5 c.c of the filtrate.

Calculation on this basis would give a minus quantity for the amount of albuminoid ammonia in G, the unpolluted water.

App. B. No. 1.

On Samples of Water purposely polluted with Excrements, etc.; by Dr. Cory.

Experiment IV.

On the 1st December 1881 four bottles were prepared. One, labelled K, contained Lambeth Company's water drawn from a house cistern on the 1st December 1881. Ki. contained the same water and 2 c.c. of fresh and healthy urine. The other two bottles were labelled L and M, and each contained the same quantity of the same water and 4 c.c. of the same urine.

The sample of urine used had at 10° C. a specific gravity of 1020, and when 20 c.c., which weighed 20·4 grammes, were evaporated to dryness, the dried residue weighed ·792 gramme, and contained 22·69 per cent. of nitrogen as determined by direct experiment.

Samples K, Ki, and L were sent to Dr. Dupré for analysis on the 1st December 1881, but M was not sent until the 7th February 1882, (the bottle, having a capacity of about 2750 c.c., and therefore not quite filled, was closely stoppered during the interval of 65 days).

The results of the chemical analyses follow:—

	K.	Ki.	L.	M.
Urine obtained Dec. 1st.	Lambeth water from house cistern drawn Dec. 1st, 1881. Examined Dec. 1st, 1881.	2000 c.c. of Lambeth water from house cistern, drawn Dec. 1st, 1881, to which were added 2 c.c. of urine. Examined Dec. 1st 1881. Pollution by solids of urine =2·77 grs. per gallon.	2000 c.c. of Lambeth water from house cistern, drawn Dec. 1st, 1881, to which were added 4 c.c. of urine. Examined Dec. 1st, 1881. Pollution by solids of urine =5·54 grs. per gallon.	2000 c.c. of Lambeth water from house cistern drawn Dec. 1st, 1881, to which were added 4 c.c. of urine. Examined Feb. 7th, 1882. Pollution by solids of urine =5·54 grs. per gallon.
Appearance	Clear	Turbid	Turbid and opalescent.	Clear.
Colour	Greenish brown	Greenish brown	Greenish brown	Strong greenish yellow.
Deposit	Minute trace	Minute trace	Minute trace	None.
Nitrous acid	None	None	None	Very much.
Phosphoric acid	Trace	Very much	Very much	Much.
Colour of residue	Yellowish	Brownish	Brownish	Pale yellowish.
Behaviour of residue on ignition.	Blackens slightly	Blackens markedly and evolves a urinous smell.	Blackens strongly and evolves a urinous smell, and one of burning nitrogenous substances.	Blackens slightly.
	Grains per gallon.			
Oxygen absorbed from permanganate in 4 hours.	0·148	0·248	0·393	0·879
Oxygen absorbed from permanganate in ½ hour.	0·061	0·165	0·239	0·836
Total dry residue	18·72	23·24	23·52	19·9
Consisting of volatile matters.	2·24	2·52	3·64	1·3
Consisting of fixed salts	16·48	20·72	19·88	18·6
Chlorine	1·22	1·82	1·89	1·89
Nitric acid	0·67	1·10	0·49	2·37*
Ammonia	0·001	0·051	0·102	0·0300
Albuminoid ammonia	0·010	0·254†	0·541†	0·0375

* All, or nearly all, in the form of nitrous acid.
† Evolution of albuminoid ammonia cannot be brought to an end.

The above results show, firstly, that when water is polluted with fresh urine only a small part of the nitrogen contained in the urine is converted into ammonia by the ammonia process as usually conducted.* (Wanklyn and Chapman, 5th edition, p. 39). Secondly, they show some of the chemical alterations induced in such water by keeping it for 65 days.

With regard to the first point:

By calculation, from the data previously given, we shall find that the increment of nitrogen added to sample Ki was equivalent to ·009 gramme per litre and in sample L to ·018 gramme per litre, or expressing these amounts in grains per gallon to ·63 grain in the former and to 1·26 grains in the latter sample. Now, if the "albuminoid ammonia process" converted the whole of the nitrogen contained in the polluted waters into ammonia, we should have $\cdot 63 \times \frac{17}{14} = \cdot 765$ gr. per gallon of albuminoid ammonia to look for in sample Ki, and twice this amount, or 1·53 grains, in sample L; but if we glance at the results of the analysis we find only ·254 grain of albuminoid ammonia for sample Ki and ·541 grain for sample L, and these figures are three times too small in the former case, and nearly three times too small in the latter. It is true that Dr. Dupré states that the evolution of ammonia could not be brought to an end in the two samples under review.

With regard to the second point:

The effects of keeping the water for 65 days are shown by the comparison of analysis L with analysis M. They were, firstly, a great increase in the amount of free ammonia, due no doubt to the decomposition of the urea giving rise to carbonate of ammonium. The amount of free ammonia is now so large that it, together with the "albuminoid ammonia," will account for two-thirds of the total nitrogen added as urine. Secondly, an increase in the amount of nitrous acid (shown under the head of nitric acid); this increase will fully account for the remainder of the nitrogen. Thirdly, a diminution of the total solids by 3·62 grains per gallon, and this also receives its explanation on the supposition of the decomposition of urea resulting in the formation of carbonate of ammonium, which latter substance being volatile would be lost on evaporation. Fourthly, a marked decrease in the amount of albuminoid ammonia; and, fifthly, an increase in the amount of the oxygen absorbed from permanganate of potass.†

Sub-experiments to ascertain the Behaviour of Urea under certain Conditions.

In connexion with the behaviour of urine when submitted to the "ammonia process" as in the last experiment, it was thought desirable

---

* But on this point Dr. Dupré's observations, in the sketch he hereafter gives of his method, deserve to be noted.

† Somewhat different results are to be noticed in another experiment detailed in this footnote. The water was kept, however, only 22 days instead of 65.

On the 24th February 1880 three bottles were prepared. One, labelled κ, contained two litres of Lambeth Company's water, drawn on the 24th, and 2 c.c. of fresh and healthy urine of specific gravity 1024. The other two bottles were labelled λ and μ, and each contained the same quantity of the same water, and 4 c.c. of the same urine.

κ and λ were sent to Dr. Dupré for analysis on the 24th February, but μ was not sent until the 16th of March (the bottle, having a capacity of 2730 c.c., and therefore not quite filled, was closely stoppered during the interval).

[*Note* † *continued on next page.*]

to learn something of the behaviour of pure urea when submitted to the same process, especially as Mr. Wanklyn states that urea gives no ammonia when treated with a strongly alkaline solution of permanganate (*see* pages 167 and 168 of the 5th edition of his book).

To this end I dissolved ·5 gramme of pure urea in 1000 c.c. of distilled water, and added 100 c.c. of this solution to 900 c.c. of distilled water. This dilute solution would contain 50 parts of urea per million. Half a litre of this dilute solution was submitted to the "ammonia process," as described on page 30 of Mr. Wanklyn's book. No carbonate of soda was added. The result was—

Free ammonia:		Milligrams.
1st	50 c.c. of distillate contained	·00923
2nd	" " "	·01278
3rd	" " "	·013135
4th	" " "	·013845
		·04899

Albuminoid ammonia:		
1st	50 c.c. of distillate contained	·01704
2nd	" " "	·01668
3rd	" " "	·01633
		·05005

[*Note † continued from previous page.*]

The results of the chemical analysis follow :—

The urine from a healthy man, obtained on the 24th February.	κ. Polluted with 2 c.c. of urine. Water drawn on the 24th Feb. Examined Feb. 26th. Pollution = 3·82 grains of solids per gallon.	λ. Polluted with 4 c.c. of urine. Water drawn on the 24th Feb. Examined Feb. 26th. Pollution = 7·64 grains of solids per gallon.	μ. Polluted with 4 c.c. of urine. Water drawn on the 24th Feb. Examined March 19th. Pollution = 7·64 grains of solids per gallon.
Appearance	Slightly turbid	Turbid	Clear
Colour	Pale brownish	Pale brownish	Strong greenish yellow.
Deposit	None	None	None.
Nitrous acid	None	None	Very much.
Phosphoric acid	Very much	Very large quantity	Very much.
Colour of residue	Brownish	Brownish	Pale brownish.
Behaviour of residue on ignition.	Blackens much	Blackens very much	Blackens perceptibly
	Grains per gallon.		
Oxygen absorbed from permanganate.	0·6440	1·288	0·322
Total dry residue	24·78	26·04	25·76
Volatile matters	4·48	6·44	3·36
Fixed salts	20·30	19·60	22·40
Chlorine	1·505	1·855	1·750
Nitric acid	0·35	0·24	0·140
Ammonia	0·0840	0·1092	1·623
Alb. ammonia	0·1862	0·2800	0·1638

The differences to be noticed are that the figures representing the amount of oxygen absorbed from permanganate of potash and the figures given under the head of nitric acid are decreased instead of increased.

Therefore in one litre there was—	Parts per Million.
Free ammonia - - - - -	·09796
Albuminoid ammonia - - - -	·10010
Total ammonia - - - -	·19806

Now, if all the nitrogen of the urea was converted into ammonia, there would be, in a million parts of water, 28·3 parts of ammonia, and this amount is represented in the analysis by ·19806 part, that is, by only $\frac{1}{141}$ of the whole possible quantity. Mr. Wanklyn's statement, therefore, that urea yields no ammonia appears to be substantially correct, but yet not quite accurate; moreover, it will be seen that his practice of estimating the free ammonia by reckoning the last three 50·c.c. of distillate as always containing one third the quantity of ammonia contained in the first 50 c.c., is not to be depended upon when urea is in question, for, as can be seen, the three last 50 c.c. of distillate contained increasing and not diminishing quantities of ammonia.

Let it be noticed, also, that if the free ammonia had been estimated in the way recommended by Mr. Wanklyn, there would have appeared ·00923 + ·00307 × 2 = ·0246 parts of free ammonia per million, instead of ·09796; and that the free ammonia thus estimated would have been to the albuminoid ammonia in a proportion of as 1· : 4·11. I shall presently have to refer to this.

In another experiment I dissolved ·0884 gramme of pure urea in 2000 c.c. of Trafalgar Square water, drawn from a tap in the New Government Offices. This solution would therefore contain 44·2 parts per million of urea, besides the impurities belonging to the water. A sample of the polluted water, and one of the Trafalgar Square water, were sent to Dr. Dupré for analysis with the following results:—

Increments occasioned by the addition of 44·2 parts of urea per million—

	Parts per Million or Milligrams per Litre.
Total dry residue - - - - -	None.
Free ammonia - - - - -	·52
Albuminoid ammonia* - - - -	2·13

Firstly, it will be noticed that apparently the impurities of the water have occasioned a much larger proportion of ammonia to be formed from the urea, and this notwithstanding Dr. Dupré's estimation of the free ammonia according to Mr. Wanklyn's directions.

Secondly, it will be observed that the proportion of free ammonia to albuminoid ammonia is as 1· : 4·09, a proportion almost exactly the same as in the former experiment, when the free ammonia was estimated in the ordinary way.

Lastly, it will be noticed that 44·2 parts per million, or 3·094 grains per gallon of urea give no increment to the total dry solids when dissolved in Trafalgar Square water. Dr. Dupré, to be certain of this fact, tried another experiment with precisely the same results. The same, however, was not the case when I substituted distilled water for Trafalgar Square water.

* The evolution of albuminoid ammonia could not be brought to an end.

Experiment V.

A man, aged 34, in good health, was placed upon milk diet on the 16th of February. He last partook of solid food on the evening of the 15th.

During the 16th he had 1740 c.c. of milk, and 480 c.c. of clear beef tea.

During the 17th he had 2180 c.c. of milk, and 270 c.c. of clear beef tea.

During the 18th he had 1950 c.c. of milk, and 540 c.c. of clear beef tea.

Thirty-six hours after the last meal of solid food the fæces had become very pale yellow in colour, resembling in this respect typhoid stools, and they remained of this colour during the continuance of the milk diet.

On the morning of the 19th, the man being still on milk diet, 1 grm. of the fæces was taken and thoroughly mixed with 100 c.c. of Lambeth water, drawn on the 18th; 5 c.c. and 10 c.c. of this liquid were added to the bottles labelled N and O respectively, each bottle containing two litres of the water drawn on the 18th.

The experiment was arranged so as to be comparable with experiment I, and it was made for the purpose of observing whether the "ammonia process" or the microscope would show any difference between a typhoid stool and a healthy stool mixed in water under similar conditions.

The samples were sent to Dr. Dupré on the 19th of February, and the remainder of the liquid, not added to the water, was sent without further dilution to Mr. Stewart on the 19th.

The following is the result of Dr. Dupré's analysis :—

In the first column of the table the results of the analysis of G, an unpolluted water, is again given for comparison. The water for experiment III. and the present one was drawn at the same time.

Stool obtained on the morning of the 19th of Feb.	G. Unpolluted water drawn on the 18th of Feb.	N. 2065 c.c. of water polluted with ·05 grm. of healthy stool. Water drawn on the 18th Feb. Pollution = 1·75 grs. per gallon.	O. 2010 c.c. of water polluted with ·1 grm. of healthy stool. Water drawn on the 18th Feb. Pollution = 3·5 grs. per gallon.
Appearance	Clear	Turbid	Turbid.
Colour	Brownish green	Brownish	Brownish.
Deposit	None	Minute trace	Trace.
Nitrous acid	None	None	None.
Phosphoric acid	Slight trace	Strong trace	Very strong trace.
Colour of residue	Brownish	Brownish	Brownish.
Behaviour of residue on ignition.	Blackens very slightly	Blackens strongly	Blackens strongly.
	Grains per gallon.		
Oxygen absorbed from permanganate.	0·1284	0·3001	0·2817
Total dry residue	23·24	23·80	24·08
Volatile matter	1·68	3·64	3·36
Fixed salts	21·56	20·16	20·72
Chlorine	1·085	1·085	1·155
Nitric acid	0·63	0·61	0·56
Ammonia	0·0016	0·0031	0·0042
Alb. ammonia	0·0064	0·0126	0·0280

The waters were allowed to stand at rest for 24 hours, and the water without the deposit was taken for analysis.

[Mr. STEWART'S EXAMINATION of the MIXTURE with which N and O were polluted.

February 20th.

Like the mixture with which E and F were polluted. (*See* Plate, fig. 2.)

Crowded with bacteria in active zoogloea state.

Granular masses like *e*, but no vibrios like *b*.]

In order to compare the results of the chemical analysis of the typhoid stool given in experiment I., with those of the healthy stool of experiment V., the following table has been made by subtracting the amount of the different substances found in the unpolluted waters from the amount of similar ones found in the polluted waters; that is to say, the figures in column A, experiment I., have been subtracted from those of columns B and C, and the figures in column G have been subtracted from those in columns N and O. It should be stated that for both experiments the typhoid stool and the healthy stool were semi-solid, and that the waters were allowed to settle, and only the supernatant water taken for analysis.

Increments indicated by analysis to have been gained by additions of known quantities of material to a gallon of water.	B. minus A. Polluted with ·06 grm. of Typhoid stool.	N. minus G. Polluted with ·05 grm. of Healthy stool. Milk Diet.	C. minus A. Polluted with ·1 grm. of Typhoid stool.	O. minus G. Polluted with ·1 grm. of Healthy stool. Milk Diet.
	Chemical Increments in Grains per Gallon.			
Oxygen absorbed by permanganate of potash	Not comparable, owing to changes of method; *see* Dr. Dupré's note.			
Total dry residue	·0	·56	·28	·84
Volatile matters	1·12	1·96	1·12	1·68
Fixed salts	−1·12	−1·40	−·84	−·84
Chlorine	·0	·0	·0	·07
Nitric acid	·0	−·08	·0	−·07
Ammonia	·0004	·0015	·0006	·0026
Alb. ammonia	·0020	·0059	·0048	·0216

From inspection of the table it will be apparent that when circumstances of diet were arranged so as to interfere as little as possible with the comparison, the addition of typhoid stool gave to water far less indication of pollution than was given by an equal quantity of healthy stool; that this was very markedly the case when the quantity of albuminoid ammonia was regarded as the measure of the added impurity. Or if chlorine were taken as the test, some indications (unimportant, it is true) of the presence of pollution were observable in the case of healthy fæcal matter being added; but not at all in the case of typhoid fæces being added.

EXPERIMENT VI.

On the 25th of February four bottles labelled P, Q, R, and S, were prepared. P and R each contained, besides 2 litres of Lambeth water, drawn on the 25th of February, ·2 grm. of typhoid stool from Joshua B., and 2 c.c. of healthy urine. Q and S each contained the same amount of water, ·4 grm. of the same typhoid stool, and 4 c.c. of the same urine.

The specific gravity of the urine was 1030. P and Q were sent to Dr. Dupré for analysis on the 26th of February, and R and S on the 4th of March.

APP. B. No. 1.

On Samples of Water purposely polluted with Excrements, etc.; by Dr. Cory.

Besides the above, two other samples were prepared on the same day, and labelled T and U. These were identical with P and Q respectively in all respects, except that they contained no urine. They were sent for analysis on the 25th February.

The results of the analyses are given below.

The proportion of fæces to urine in the samples P, Q, R, and S, was arranged in accordance with the customary estimate, which is that the average weight of urine passed by men is 10 times the average weight of fæces.

All these samples were polluted with the stool of Joshua B., obtained on the morning of 25th of Feb. The stool was semi-solid. The urine used was that from a healthy man, obtained on the 25th of Feb.	P. Two litres of water polluted with ·2 grm. of typhoid stool, and 2 c.c. of urine. Water drawn on the 25th Feb. Sent on the 26th of Feb.	Q. Two litres of water polluted with ·4 grm. of typhoid stool, and 4 c.c. of urine. Water drawn on the 25th Feb. Sent on the 26th of Feb.	R. Two litres of water polluted with ·2 grm. of typhoid stool, and 2 c.c. of urine. Water drawn on the 25th Feb. Sent on the 4th March.	S. Two litres of water polluted with ·4 grm. of typhoid stool, and 4 c.c. of urine. Water drawn on the 25th Feb. Sent on the 4th of March.	T. Two litres of water polluted with ·2 grm. of typhoid stool. Water drawn on the 25th Feb. Sent on the 25th Feb.	U. Two litres of water polluted with ·4 grm. of typhoid stool. Water drawn on the 25th Feb. Sent on the 25th Feb.
Appearance	Turbid	Turbid	Turbid	Turbid	Turbid	Turbid.
Colour	Brownish	Brownish	Brownish	Brownish	Pale brownish.	Brownish.
Deposit	Trace	Trace	A little	A little	Trace	Trace.
Nitrous acid	None	None	Much	Very much	None	None.
Phosphoric acid	Very much	Very large quantity.	Very much	Large quantity.	Much	Much.
Colour of residue	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish.
Behaviour of residue on ignition	Blackens much.	Blackens much.	Blackens much.	Blackens much.	Blackens much.	Blackens much.
	Grains per gallon.					
Oxygen absorbed from permanganate.	0·9016	1·5456	·5796	·6440	0·483	0·644
Total dry residue	25·62	27·44	24·50	27·16	22·68	23·66
Volatile matters	3·50	5·32	3·64	5·32	4·48	2·84
Fixed salts	22·12	22·12	20·86	21·84	18·20	20·96
Chlorine	1·575	1·890	1·505	1·855	1·120	1·155
Nitric acid	0·42	0·28	0·350	0·210	0·49	0·42
Ammonia	0·0696	0·1470	0·4760	0·7770	0·0084	0·0116
Alb. ammonia	0·1865	0·3732	0·3145	0·4200	0·0372	0·0560

It may be observed that the results of keeping the polluted water for eight days were an increase in the amounts of nitrous acid and free ammonia, and a decrease in the amounts of oxygen absorbed from permanganate of potassium, the total solids and albuminoid ammonia.

In experiment IV. (compare analyses L and M), in which urine alone was used, and the water kept for 65 days before analysis, an increase is also noticeable in the amount of nitrous acid and free ammonia, and a decrease in the amount of total solids; but the oxygen absorbed from permanganate of potassium is increased instead of being diminished, and the albuminoid ammonia is decreased instead of increased.

SUB-EXPERIMENTS to determine the PROPORTION of CHLORINE secreted in the URINE of PATIENTS suffering from TYPHOID FEVER as compared with that in HEALTHY URINE.

On the 19th of March the chlorine in 5 c.c. of the urine of a healthy man, who weighed 82·89 kilos, was determined.* It was found to

* The determination was made by evaporating 5 c.c. of urine to dryness on a water bath, igniting the residue at a moderate heat, dissolving the ignited residue in distilled water with the aid of a little nitric acid, neutralising and then running into the solution a standard solution of nitrate of silver, using chromate of potass as an indicator.

amount to ·027 grm. Taking 1500 c.c. as the average quantity of urine secreted per diem, we should obtain 8·1 grms. of chlorine as the amount secreted by the above man per diem. Dr. Foster gives 7· to 8·21 grms. per diem as the normal quantity of chlorine for an average man of 66 kilos to secrete.

On the 22nd March the chlorine in 5 c.c. of the urine of a man, Thomas Parker, aged 21, suffering from typhoid fever of 13 days' duration, was determined. His average temperature, the mean of six observations, on the previous day had been 39°·4 C. (102°·9 F.). It was found to amount to ·0086 grm.

If this man had passed the same quantity of urine as the healthy man of experiment V. (typhoid fever patients usually pass less), the chlorine secreted by him in a day would have been 2·58 grms.

On the 9th April the chlorine in 5 c.c. of the mixed urine of a man, Richard Cook, aged 26, suffering from typhoid fever of 10 days' duration, was determined. His average temperature, the mean of six observations, on the previous day had been 40°·12 C. (104°·2 F.). It was found to amount to ·0186 grm., and he passed on the same day 1391 c.c. of urine; thence the total amount of chlorine passed by this man in 24 hours was 5·1745 grms.

The amount of chlorine passed by these two typhoid patients is thus seen to be considerably below the normal.

Experiment VII.

The following samples were prepared in order to determine the amount of organic carbon and organic nitrogen contained in them by the methods of Dupré and Halke for the carbon, and Dittmar for the nitrogen:—

V was unpolluted Lambeth water, drawn on the 11th of March.
W contained ·2 grm. of typhoid stool in 2 litres of water, equivalent to 7 grains per gallon.
X contained ·4 grm. of typhoid stool in 2 litres of water, equivalent to 14 grains per gallon.

The stool used was loose, and had been kept in a stoppered bottle for five days before being used for the pollution of the above samples. It was the same stool which had been ascertained to yield ·083 grm. of dry residue for every gramme of stool, as mentioned on page 128 of this report. It was passed on March 6th, when the patient (Cox) had been in hospital 10 days, and ill for a week before admission. Dr. Dupré was acquainted with the nature and proportion of the pollution in the samples. The samples were allowed to stand for 24 hours, and the supernatant water alone taken for analysis. The following shows the result of his analyses:—

APP. B. No. 1.

On Samples of Water purposely polluted with Excrements, etc.; by Dr. Cory.

—	V. Unpolluted water drawn on the 11th March.	W. Two litres of water polluted with ·2 grm. of typhoid stool taken on March 6th. Water drawn on the 11th March. Pollution=7 grs. per gallon.	X. Two litres of water polluted with ·4 grm. of typhoid stool taken on March 6th. Water drawn on the 11th March. Pollution=14 grs. per gallon.
Appearance	Clear	Turbid	Turbid.
Colour	Greenish yellow	Pale brownish	Pale brownish.
Deposit	Minute trace	Very little	A little.
Nitrous acid	None	None	None.
Phosphoric acid	Trace	Strong trace	Strong trace.
Colour of residue	Pale brownish	Brownish	Brownish.
Behaviour of residue on ignition.	Blackens perceptibly	Blackens strongly	Blackens strongly.
	Grains per gallon.		
Oxygen absorbed from permanganate.	0·225	0·322	0·299
Total dry residue	22·40	22·40	23·96
Volatile matters	2·24	3·08	2·80
Fixed salts	20·16	19·32	20·16
Chlorine	1·085	1·050	1·085
Nitric acid	0·630	0·630	0·700
Ammonia	0·0005	0·0026	0·0046
Alb. ammonia	0·0093	0·0120	0·0168
Organic Carbon	0·298	0·322	0·336
Organic Nitrogen	0·058	Not determined	0·137

It has been previously shown (page 129) that the dry soluble portions in 1 grm. of this typhoid stool amounted to ·061 grm. Hence, the soluble portions in 7 grains of stool would be equal to ·427 grain. The soluble material added per gallon to sample W would therefore be ·427 grain, and in sample X to ·854 grain. Now, if we deduct the amount of organic carbon and organic nitrogen contained in the unpolluted sample V from that contained in the polluted sample X, we find that the evidence of ·854 grain of soluble matter, tested by the increment of "organic carbon" and "organic nitrogen," consists of ·037 grs. of the former and ·079 of the latter.

It was of interest to observe what degree of coincidence there might be between "organic nitrogen" thus determined by Dittmar's process and the nitrogen determined as albuminoid ammonia by Wanklyn's process. The addition of ·854 grain of soluble matter gave rise to an increment between analyses V and X of ·0075 of albuminoid ammonia. Fourteen-seventeenths of this amount or ·00618 grain per gallon is the amount of nitrogen in the albuminoid ammonia. Hence ·079 grain organic nitrogen and ·00618 grain of nitrogen as albuminoid ammonia make their respective claims to be regarded as the expression of the nitrogen impurity caused by adding ·854 grain of soluble matter from a typhoid stool. The one figure is 12·6 times less than the other.

EXPERIMENT VIII.

On March 1st two samples were prepared, Y and Z.

Y contained two litres of Lambeth water polluted with 2 c.c. of healthy urine obtained on the 1st of March, and 2 c.c. of the filtrate from the typhoid stool used in experiment III. page 130.

Z contained 2 litres of Lambeth water polluted with 4 c.c. of healthy urine obtained on the 1st of March, and 4 c.c. of the filtrate.

The two samples were without odour and were similar in appearances. They were sent on the 1st of March to Mr. Stewart for examination. He was asked if he could determine by his examination the proportion of the pollution.

The results of his examination follow :—

Y, March 1st.	Z, March 1st.
Water clear, no deposit. Contained a few crustacea (entomostraca), a very few monads, and many motionless points.	Like Y.
Examined March 3rd. Water opalescent, but not offensive.	Examined March 3rd. More opalescent than Y; not offensive.
Examined March 4th. Opalescent, offensive. Crowds of bacteria, and monads.	Examined March 4th. More opalescent, *very* offensive. Crowds of bacteria, and small monads.
Examined March 7th. Slightly opalescent, not offensive. A few bacteria, and some ciliate infusoria.	Examined March 7th. But slightly opalescent; hardly any smell. Bacteria less abundant, many large monads and ciliate infusoria.

"It was possible, from a comparison of the opalescence produced in the waters by keeping, on the third day to conjecture that Z contained the most polluting material, and this conjecture was strengthened on the fourth day by the offensive odour being more powerful from Z than from Y."

It will be observed that the waters first became opalescent, accompanied with rapid multiplication of bacteria and monads; then, while still opalescent, they became offensive; and lastly, opalescence and offensiveness rapidly declined, and during their declension a decrease in the number of bacteria took place. At the same time higher forms of infusorial life began to make their appearance. Whether any special forms of organism or ova develop from typhoid stool, which has been added to water conditioned for their development, and if so, what the conditions may be, are questions which present themselves and seem worthy of further consideration.

Experiment IX.

On the 4th of March 12 litres of Lambeth water were drawn off into a large bottle, which had up to the above date been used for keeping distilled water in.

On the same date six Winchester quart bottles were washed by first rinsing them out with strong sulphuric acid, then with water, and lastly, they were each filled to overflowing and emptied three times with the Lambeth water.

On the 6th of March a loose stool was obtained from William Cox, aged 16, who was admitted into St. Thomas's Hospital on the 24th February 1880, suffering from typhoid fever of one week's duration. He was taking egg-and-brandy mixture and milk as diet, but no medicine. His average temperature on the 5th, the mean of six observations, was 39°·5 C. (103°·1 F.). The stool now in question is the one that was used in experiments I. and VII., and that had been found to contain 6·1 per cent. of soluble solid matter.

One gramme of the stool was mixed with 100 c.c. of Lambeth water, and the mixture allowed to stand for 24 hours. It was then filtered

App. B. No. 1.

On Samples of Water purposely polluted with Excrements, etc.; by Dr. Cory.

through ordinary filter paper, and the filtrate used for the pollution of the samples presently to be mentioned.

On the same day 6 of the 12 litres contained in the large bottle were poured into three of the cleansed Winchester quart bottles, 2 litres in each. These latter were labelled 1, A, and C^5 respectively.

30 c.c. of the filtrate above mentioned was then added to the remainder of the water in the large bottle, and the bottle then well shaken. The water thus polluted was then poured out into the other three Winchester quart bottles, 2 litres in each, and the bottles labelled 2, B, and C^6 respectively.

Samples 1 and 2 were sent to Mr. Wanklyn for analysis, samples A and B to Professor Frankland, and C^5 and C^6 to Dr. Dupré. None of the chemists were informed of the nature or amount of the polluting material.

The results of their analyses are shown in the following table, where the quantities are brought to grains per gallon :—*

	Unpolluted samples.			Polluted samples.		
	Dupré.	Frankland.	Wanklyn.	Dupré.	Frankland.	Wanklyn.
The stool obtained from William Cox on the morning of the 6th March.	Unpolluted Lambeth Water drawn on the 4th of March. Sent on the morning of the 8th for analysis.			Lambeth water, two litres of which had been polluted with the soluble portion of ·1 grm. of Typhoid stool known to contain ·0061 grm. of solid matter. This is in the proportion of 0·21 grain. soluble solid matter added to each gallon. Sent on morning of the 8th for analysis.		
Appearance	Clear	Clear	—	Very slightly turbid.	Clear	—
Colour	Pale brownish green.	—	—	Pale brownish yellow.	—	—
Deposit	None	—	—	None	—	—
Nitrous acid	None	—	—	None	—	—
Phosphoric acid	Strong trace	—	—	Strong trace	—	—
Colour of residue	Pale brownish.	—	—	Pale brownish.	—	—
Behaviour of residue on heating.	Blackens perceptibly.	—	—	Blackens perceptibly.	—	—
	Grains per gallon.					
Oxygen absorbed from permanganate.	0·2415	—	—	0·2512	—	—
Total dry residue	22·68	22·568	Not stated	23·24	22·96	Not stated
Consisting of volatile matters.	0·70	—	—	1·96	—	—
Consisting of fixed salts.	21·98	—	—	21·28	—	—
Chlorine	1·015	1·12	1·3	1·015	1·05	1·3
Nitric acid, N_2O_5	0·924	0·7722	—	0·770	0·8262	—
Ammonia	0·0011	0·	0·0014	0·0016	0·	0·0007
Albuminoid ammonia	0·0090	—	0·0056	0·0100	—	0·007
Organic carbon	—	·2114	—	—	·2205	—
Organic nitrogen	—	·0371	—	—	0·0399	—
Total hardness	—	15·26	18·	—	15·82	18·
Temporary	—	8·96	—	—	10·22	—
Permanent	—	6·3	—	—	5·6	—

The only figures in the table which require explanation are those given in Professor Frankland's analysis under nitric acid. In his analysis he gives the amount of nitrogen present as nitrates and nitrites,

* As I shall have occasion specially to comment on Mr. Wanklyn's results, I give the actual figures of his analyses in parts per million, as forwarded by him :—

In unpolluted sample.		*In polluted sample.*	
Ammonia	0·02	Ammonia	0·01
Albuminoid ammonia	0·08	Albuminoid ammonia	0·10

but since, in Dr. Dupré's analysis no nitrites were found, it has been assumed for Professor Frankland that no nitrites were present in his sample, and, therefore, that the nitrogen, under his heading of "nitrogen, as nitrates and nitrites," was present only as nitric acid. On this assumption and calculating the amount of nitric acid in grains per gallon, the figures given in the table are arrived at.

[Mr. Stewart reports of the filtrate from the stool of William Cox used to pollute the waters sent to Messrs. Dupré, Frankland, and Wanklyn :—

March 7th.—Turbid; pale fawn coloured; faint, but not offensive smell. Contained crowds of bacteria, and other minute schizomycetous fungi.

March 9th.—Smell a little stronger, but hardly offensive. Forms as before, but a few large monads also present.]

Experiment X.

On the 9th of April 1880, three bottles were prepared, each containing two litres of the Lambeth Company's water, drawn on the same day. These were labelled AA, BB, and CC; AA was left unpolluted, BB was polluted with 3·86 grms. of a typhoid stool obtained from Richard C. on the 9th of April. CC was polluted as follows: first, 3·86 grms. of the same stool were added to two litres of the same water, and ·308 grm. of chloride of sodium was also added. A filter was made by placing one end of a drain pipe, 2 feet long by 6 inches internal diameter, into an earthenware funnel of suitable size. The funnel was then filled with pumice stone and tow, and the drain pipe having been placed in position, it was filled to the height of 18 inches with clean sand. Through this filter Lambeth water was passed for several days before it was used, and on the 9th April, the day on which it was used for the experiment, 3 litres of the water were passed through. After the 3 litres had passed, and the filter no longer dripped, the mixture of water, stool, and chloride of sodium was poured into the filter. The first half-litre which now passed was poured back into the filter. When this was done there was no fluid on the surface of the sand, for the whole of it had been soaked up by the sand. The filter was now allowed to stand until it had finished dripping, and the water which passed was collected as sample CC. It was found to measure very nearly two litres. The three samples were sent on the 10th of April to Dr. Dupré for analysis, and the results are given in the following table :—

	AA. Unpolluted water drawn on the 9th April.	BB. Two litres of water polluted with 3·86 grms. of typhoid stool. Pollution = 135·1 grs. of stool, or 11·308 of dried stool per gallon.	CC. Two litres of water obtained from the filter under circumstances mentioned in the text.
Appearance	Clear	Very turbid	Clear.
Colour	Very pale greenish	Brownish	Almost colourless.
Deposit	None	Much	None.
Nitrous acid	None	Strong trace	None.
Phosphoric acid	Slight trace	Very much	Trace.
Colour of residue	Very slightly yellowish.	Brownish	Slightly yellowish.
Behaviour of residue on ignition.	Blackens very slightly.	Blackens very strongly.	Blackens slightly.

APP. B, No. 1.

On Samples of Water purposely polluted with Excrements, etc.; by Dr. Cory.

	AA. Unpolluted water drawn on the 9th April.	BB. Two litres of water polluted with 3·86 grms. of typhoid stool. Pollution = 135·1 grs. of stool, or 11·308 of dried stool per gallon.	CC. Two litres of water obtained from the filter under circumstances mentioned in the text.
	Grains per gallon.		
Oxygen absorbed from permanganate.	0·217	1·240	0·279
Total dry residue	20·70	25·90	21·84
Volatile matters	1·68	5·60	3·36
Fixed salts	19·02	20·30	18·48
Chlorine	1·085	1·065	1·295
Nitric acid	0·64	Trace.	0·56
Ammonia	0·000	0·0924	0·000
Alb. ammonia	0·0042	0·0329	0·0062

With regard to the stool with which the two bottles BB and CC were polluted. It was obtained, as stated, from Richard C., on the 9th of April. This man was admitted into St. Thomas's Hospital on the 7th April. He was 26 years of age, and had been ill nine days. He was taking milk and beef tea, but no medicine. His temperature on the 8th had averaged 40° C. (104° F.). It was found that when 3·95 grms. of this stool were desiccated in an exhausted bell glass in the presence of sulphuric acid, the residue weighed ·33 grm. The proportion, therefore, of solid dry matter contained in the fæces dried in this manner was as ·0837 : 1, a proportion almost exactly that found in another stool mentioned on page 128 of this report. Now as BB contained 3·86 grms. of stool in two litres of water, the proportion of solid dry stool would be 11·308 grains per gallon. This would include, of course, both soluble and insoluble matters; data have, however, been given on page 129 to show that such a typhoid stool yields 6·1 per cent. of soluble matters. Applying this percentage, we calculate that there would be about 8·24 grains per gallon of soluble matter added to sample BB. The reason for adding the chloride of sodium to the polluted water which it was intended to pass through the filter, was for the purpose of proving by its re-appearance in the filtered water that some of the polluted water had actually passed.

It had been ascertained that the unpolluted water, previously passed through the filter, contained the same amount of chlorine after as it did before filtration. A certain quantity of water was always retained by the filter. When, therefore, the polluted water was poured in, the first water that dripped from the filter would be the previously retained unpolluted water. This, to the amount of half a litre, was therefore returned to the filter. As the event showed, however, this quantity was not sufficient, for the amount of chlorine found in sample CC was only equivalent to 1·295 grains per gallon, and if from this we deduct the amount of chlorine contained in the unpolluted sample AA, we get ·210 grain per gallon, whereas the proportion of chlorine added before filtration was 6·54 grains per gallon, hence we conclude that only $\frac{\cdot 210}{6 \cdot 54} =$ ·0321 of the polluted water was present in sample CC when sent for analysis. Instead, therefore, of the pollution being equivalent to 135·1 grains per gallon of typhoid stool, as in BB, it would only be equal to 4·34 grains per gallon in CC; and on the supposition that the soluble polluting materials passed through the filter in the same proportion as

the chlorine, we have theoretically the following quantities calculated from those found in sample BB, which for the sake of comparison are placed side by side with those actually found in CC :—

	Theoretical.	Found.
Oxygen absorbed from permanganate	·2497	·2790
Total dry residue	21·07	21·84
Volatile matters	1·80	3·36
Fixed salts	19·27	18·48
Nitric acid	—	0·56
Ammonia	·001	·000
Alb. ammonia	·0052	·0062

It is to be observed, however, in the analysis of BB, that the amount of albuminoid ammonia is very small in proportion to the large amount of pollution. Compare the amount of albuminoid ammonia in analysis F (page 129) with BB.

Experiment XI.

On February 7th, 1881, three samples of water were prepared in bottles labelled DD, EE, and FF.

DD contained only Lambeth water drawn from the cab-rank, Westminster Bridge Road, on the 4th of February.

EE contained 2 litres of distilled water, to which had been added 2 c.c. of egg-albumen. It was ascertained that 4 c.c. of this egg-albumen weighed 4·292 grms., and when completely desiccated by being placed under an exhausted bell glass, together with a vessel containing strong sulphuric acid, it weighed ·580 grm., hence 2 c.c. the amount of albumen added to sample EE, would weigh when desiccated ·290 grm., and this would be equivalent to 10·15 grains of egg-albumen per gallon.

FF contained 2 litres of the same Lambeth water as DD, and 2 c.c. of the same egg-albumen as EE.

The following is the result of Dr. Dupré's analysis :—

	DD. Lambeth water from Cab-rank, Westminster Bridge Road, February 4th, 1881.	EE. 2000 c.c. of distilled water, to which had been added 2 c.c. of egg-albumen. Pollution = 10·15 grs. of dried egg-albumen per gallon.	FF. 2000 c.c. of Lambeth water of February 4th, to which had been added 2 c.c. of egg-albumen. Pollution equal to 10·15 grs. of dried egg-albumen per gallon.
Appearance	Clear	Turbid	Turbid.
Colour	Brownish	Very pale brownish	Brownish.
Deposit	None	Little. White flocculent.	Little. White flocculent.
Nitrous acid	None	None	None.
Phosphoric acid	Much	Very strong trace	Very strong trace.
Colour of residue	Light brownish	White	Light brownish.
Behaviour of residue on heating.	Blackens slightly	Much carbon separated. Strong smell of burning nitrogenous matter.	Much carbon separated. Strong smell of burning nitrogenous matter.
	Grains per gallon.		
Oxygen absorbed from permanganate.	0·134	0·731	0·901
Total dry residue	20·16	10·92	29·4
Consisting of Volatile salts	3·36	9·8	11·48
Consisting of Fixed salts	16·8	1·12	17·92
Chlorine	1·03	·14	1·16
Nitric acid	0·26	None.	0·06
Ammonia	0·0000	0·0224	0·0101
Albuminoid ammonia	0·0112	0·597	0·6587

It is obvious that if egg-albumen suffers no other change from being mixed with Lambeth water than it may do from being mixed with distilled water, and if it produces no change in the impurities contained in the Lambeth water, then we ought to obtain the quantities given in EE by deducting the quantities given in DD from those given in FF: or obtain the quantities given in FF by adding those given in DD and EE.

The following table shows the results when the latter is done:—

——	Calculated Amounts.	Amounts found.
Oxygen absorbed - -	·134 + ·731 = 0·865	0·901
Total dry residue - -	20·16 + 10·92 = 31·08	29·4
Consisting of { Fixed salts -	16·8 + 1·12 = 17·92	17·93
Consisting of { Volatile salts	3·36 + 9·8 = 13·16	11·48
Chlorine - - -	1·02 + ·14 = 1·16	1·16
Nitric acid - - -	·26 + ·0 = ·26	·06
Ammonia - - -	·0 + ·0224 = ·0224	·0161
Albuminoid ammonia -	·0112 + ·597 = ·6082	·6587

These results are therefore fairly consistent, except in the case of the nitric acid, which is more than four times less than the quantity calculated. This result appears also in other analyses and will be again referred to.

Experiment XII.

On February 15th five samples of water were prepared. The bottles containing these were labled GG, HH, JJ, KK, and LL.

GG contained only Lambeth water drawn from house cistern on the 14th of February 1881.

HH, JJ, and KK were prepared as follows:—

Four litres of the same sample of Lambeth water as GG were poured into a large bottle and 2 c.c. of blood serum, which had separated from some human blood obtained on the 14th February were added. The large bottle was shaken up and 2 litres of the mixture were then transferred to a Winchester quart bottle and labelled KK. To the remainder of the mixture another litre of the same Lambeth water was added and shaken, and two litres of this diluted mixture were transferred to a Winchester quart bottle labelled JJ. The remainder of the diluted mixture was further diluted by adding another litre of the same Lambeth water to it, and the whole of this, consisting of 2 litres, was transferred to a Winchester quart bottle labelled HH. Thus KK contained 1 c.c. of blood serum in 2 litres of Lambeth water, JJ contained $\frac{2}{3}$ c.c. of blood serum in 2 litres of Lambeth water, and HH contained $\frac{1}{3}$ c.c. of blood serum in 2 litres of Lambeth water.

Four c.c. of the same blood serum as used above weighed 4·124 grms., and when thoroughly desiccated under a bell glass in the presence of

sulphuric acid they weighed ·436 grm., hence KK contained ·109 grm. of solid dry serum dissolved in 2 litres of Lambeth water, equivalent to 3·815 grains per gallon; JJ contained $\frac{2}{3}$ of this amount, that is, 2·543 grains per gallon; and HH contained $\frac{1}{3}$ of the amount, that is, 1·272 grains per gallon.

LL was prepared as follows:

Two c.c. of blood serum were added to 198 c.c. of distilled water, and 100 c.c. of this mixture were then poured into a litre measure, which was filled up with distilled water to within 200 c.c. of the litre mark. 20 c.c. of normal nitre solution (prepared by dissolving 1·011 grains of nitre in 1000 c.c. of distilled water) were then added, as well as 50 c.c. of standard solution of chloride of calcium (prepared by dissolving 1 grain of Iceland spar in hydrochloric acid, evaporating the solution to drive off excess of hydrochloric acid, and then dissolving the residue in as much distilled water as made the solution measure 1 litre). After these were added the litre measure was filled up to the litre mark, and the mixture was transferred to a Winchester quart bottle. Lastly, another litre of distilled water was poured into the Winchester quart bottle.

LL, therefore, in the volume of 2 litres contained distilled water polluted with 1 c.c. of blood serum, that is, with ·109 grm. of solid dry serum, equivalent to 3·815 grains per gallon; with 20 c.c. of normal nitre solution (containing 1·011 grms. in 1000 c.c. of distilled water), that is, with ·02022 grm. of nitre, equivalent to ·7077 grains per gallon; with 50 c.c. of standard solution of chloride of calcium (containing 1·65 grms. of $CaCl_2 + 3H_2O$* in 1000 c.c. of distilled water), that is, with ·0825 grm. of $CaCl_2 + 3H_2O$, equivalent to 2·8875 grains per gallon.

The amount of nitric acid (N_2O_5) in a water containing ·7077 grains of KNO_3 per gallon is $\frac{28+80}{39·1+14+48} \times ·7077 = ·378$ grain per gallon.

The amount of chlorine in a water containing 2·8875 grains of $CaCl_2 + 3H_2O$ per gallon is $\frac{71}{40+71+6+48} \times 2·8875 = 1·273$ grains per gallon.

The amount of chlorine in ·0545 grm. of dried blood serum was ascertained to be ·002 grm., hence the serum added ·14 grain of chlorine per gallon, which must be added to obtain the total amount of chlorine pollution in sample LL.

* The water of crystallization retained by the $CaCl_2$ when dried at 100° C. was determined and found to be three equivalents.

	GG.	HH.	JJ.	KK.	LL.
	Lambeth Water from Cistern, February 14, 1881.	2000 c.c. of Lambeth water + ¼ c.c. of blood serum = 1·272 grains per gallon of dried blood serum.	2000 c.c. of Lambeth water + ¾ c.c. of blood serum = 2·545 grains per gallon of dried blood serum.	2000 c.c. of Lambeth water + 1 c.c. of blood serum = 3·815 grains per gallon of dried blood serum.	gra. per gallon. 1929 c.c. of distilled water + 1 c.c. of blood serum - = 3·815 + 50 cc. of standard solution of chloride of calcium - = 2·865 + 20 c.c. of normal nitre solution - = ·707 Total solids in sample - = 7·4102 Nitric acid pollution contained in the nitre - = ·37 Chlorine pollution contained in the chloride of calcium - - = 1·273 + ·14 grain contained in the blood serum - = 1·413
Appearance -	Clear - -	Slightly turbid -	Turbid - -	Slightly turbid -	Very turbid.
Colour - -	Rather deep brownish.	Rather deep brownish.	Rather deep brownish.	Rather deep brownish.	Very pale brownish.
Deposits -	None - -	Trace - -	Trace - -	Trace - -	None.
Nitrous acid -	None - -	None - -	None - -	None - -	None.
Phosphoric acid	Strong trace -	Very strong trace	Strong trace -	Very strong trace	Strong trace.
Colour of residue.	Brownish -	Brownish -	Brownish -	Brownish -	Brownish.
Behaviour of residue on heating.	—	Blackens very strongly and evolves smell of burning nitrogenous matter.	Blackens strongly and evolves urinous smell.	Blackens very strongly and evolves smell of burning nitrogenous matter.	Blackens very strongly and evolves smell of burning nitrogenous matter.
	Grains per gallon.				
Oxygen absorbed from permanganate -	0·14	0·244	·372	·463	·297
Total dry residue - -	19·6	21·56	23·24	24·36	*7·23
Consisting of:					
Volatile salts	1·96	3·08	4·76	5·88	5·04
Fixed salts -	17·64	18·48	18·48	18·48	2·23
Chlorine -	1·11	1·14	1·18	1·18	1·26
Nitric acid -	·53	0·47	0·29	0·17	0·06
Ammonia -	·0014	·0014	0·0084	0·0056	0·0090
Albuminoid ammonia.	·0112	0·1405	0·2624	0·4127	0·2066

* The calculated weight of dry residue was 7·4102 grains per gallon.

Now it is clear that if the inorganic salts contained in LL produce no change in the condition of the organic matter, *i.e.*, the albumen, contained in it, we should expect to find that the chemical tests used for the determination of the amount of the organic material would indicate the same amount in LL as in KK less that contained in GG.

The following table gives the actual result :—

	KK minus GG.	LL.	
Oxygen absorbed from permanganate -	·323	·297	
Volatile salt - - - - - -	3·92	5·04	This difference may be partly due to 1 equivalent of H_2O which would be driven off from the $CaCl_2$ on ignition.
Albuminoid ammonia - - -	·4015	·2066	

From the above calculation it here appears that the permanganate process gave better results than the albuminoid process.

If the inorganic salts contained in a water do affect the tests whereby it is sought to determine the amount of organic matter contained in it, the fact becomes of importance when these tests are applied to waters containing large quantities of these salts, as in the case of many deep-well waters.

Another point to be observed is the apparent disappearance of the nitric acid from the samples, as the amount of albumen in them is increased. The gradual diminution in samples HH, JJ, and KK shows this very well, and in sample LL the ·378 grain per gallon contained in it is apparently reduced to ·06 grain per gallon.

Experiment XIII.

On the 20th May four samples were prepared, MM, NN, OO, PP.

MM consisted of Lambeth water of the 20th May from house cistern.

NN consisted of 5760 c.c. of distilled water to which were added 30 c.c. of a solution of egg-albumen made by mixing 5 c.c. of the egg-albumen with 50 c.c. of distilled water (4 c.c. of this egg-albumen evaporated to dryness weighed ·58 grm.; and ·0725 grm. of the dried albumen contained ·0019 grm. of chlorine), 150 c.c. of standard solution of chloride of calcium, and 60 c.c. of normal nitre solution, both the latter solutions being prepared as in the former experiment.

OO consisted of 6 litres of Lambeth water of the 20th May 1881, to which had been added 3 c.c. of urine of sp. gr. 1028.

PP consisted of 6 litres of Lambeth water to which had been added 60 c.c. of the filtrate from a typhoid stool (1 grm. of stool mixed with 100 c.c. of distilled water and filtered). Five grms. of this stool, which was a very loose one, were evaporated to dryness, and the residue was found to weigh ·29 grm. The filtrate from 5 grms. of the same stool, obtained by mixing 5 grms. with 500 c.c. of water and filtering through filter paper when evaporated to dryness weighed ·1 grm., and the insoluble residue on the filter weighed ·184 grm.

A Winchester quart bottleful of each sample was sent, one to Dr. Dupré and another to Dr. Frankland, on the same day for analysis, and every care was taken that the bottles were chemically clean before they were filled.

The following table gives the results of their analyses:—

The amounts per gallon of the polluting materials are calculated from the data given above.

—	—	Sample MM. Lambeth Water, 20th May 1881, from House Cistern.	Sample NN. Distilled Water polluted with per gallon:— ·7077 grain of KNO_3 = ·378 grain of Nitric Acid (N_2O_5). 2·8875 grains of $CaCl_2 + 3H_2O$ = 1·273 grains of Chlorine + ·133 gr. per gallon of Cl contained in the egg-albumen = 1·406 total Cl pollution. 5·075 grains of dried egg-albumen. 8·6702 total weight of polluting material.	Sample OO. Lambeth Water, 20th May 1881, polluted with Urine of specific gravity 1028 = 2·347 grains per gallon of solid matter.	Sample PP. Lambeth Water, of 20th May 1881, polluted with the filtrate of 7 grains Typhoid stool per gallon = ·14 grain of solid matter per gallon.

		Frankland.	Dupré.	Frankland.	Dupré.	Frankland.	Dupré.	Frankland.	Dupré.
	Appearance	Clear	Clear	Very clear	Very slightly turbid	Clear	Slightly turbid	Clear	Slightly turbid.
	Colour	Clear, contained moving organisms.	Pale greenish brown.	Contained moving organisms, and subsequently developed fungoid growth.	Almost colourless	—	Pale brownish	Contained moving organisms.	Pale brownish.
	Deposit		None		Minute trace	—	Minute trace		Minute trace.
	Nitrous acid		None		None	Slight trace	None		None.
	Phosphoric acid		Trace		Strong trace	—	Much		Strong trace.
	Colour of residue		Yellowish		Yellowish	—	Yellowish		Yellowish.
Frankland's published analysis of Lambeth water of the 10th May from Registrar-General's Returns.	Behaviour of residue on heating		Blackens markedly.		Much carbon separates and strong smell of burning nitrogenous matter	—	Blackens markedly.		Very little blackening.
		Grains per Gallon.							
	Oxygen absorbed from permanganate in ¼ hour	0·0441	0·0310	0·0595	0·2870	0·0616	0·0590	*0·0427	*0·036
	Oxygen absorbed from permanganate in 4 hours		0·0560		0·3640		0·0950		0·062
19·04	Total dry residue	19·012	20·720	7·840	7·840	20·020	20·300	18·620	20·440
	Consisting of Volatile salts	—	2·52	—	4·760	—	2·80	—	3·08
	Consisting of Fixed salts	—	18·20	—	3·080	—	17·50	—	17·36
1·05	Chlorine	1·05	1·02	1·47	1·53	1·33	1·26	1·05	1·02
·6237	Nitric acid N_2O_5	0·6453	0·5500	0·3348	trace	0·6453	0·1100	0·6345	0·2200
·0000	Ammonia	0·000	0·0014	0·0280	0·0045	0·1484	0·7000	0·0070	0·0017
	Albuminoid ammonia	—	0·0067	—	0·3490	—	0·0590	—	0·0060
·0994	Organic carbon	0·1071	0·3190	1·5582	2·6480	0·2835	0·7670	0·0973	0·4950
·0308	Organic nitrogen	0·0322	0·0490	0·4872	0·5760	0·4627	0·5760	0·0294	0·0450
	Hardness Temporary	8·75	—	·49	—	4·97	—	8·26	—
	Hardness Permanent	5·25	—	2·31	—	9·05	—	5·11	—
	Hardness Total	14·00	—	2·8	—	14·00	—	13·37	—

2·8875 grains of $CaCl_2 + 3H_2O$ would contain as much calcium as when combined with carbonic acid would = 1·75 grains per gallon of carbonate of calcium.

The chloride of calcium would be represented in permanent hardness as it is not precipitated by boiling.

* For comparison with MM. the figures in both these columns to be increased 1 per cent. for the 60 c.c. of distilled water added as typhoid stool filtrate.

In the above analyses there are one or two points to notice, and one is the apparently very good results that Dr. Frankland's methods for the estimation of organic carbon and organic nitrogen gave. Thus sample NN consisted of distilled water polluted with albumen which contained carbon and nitrogen in the proportion of about 10 to 3, and accordingly we find this proportion nearly maintained, viz., 1·5582 : 0·4572.

Again, sample OO was Lambeth water polluted with urine, and if we deduct the organic carbon and nitrogen which the Lambeth water contained from that which sample OO contained, we obtain ·1764 for the organic carbon, and ·4305 for the organic nitrogen which were presumably added to the water by the urine; and as urea, the chief organic constituent of urine, contains carbon and nitrogen in the proportion of three to seven, we accordingly find this proportion nearly maintained, viz., ·2835 : ·4627.

In the same connexion, it is proper to call attention to the practical identity of the results given by Dr. Frankland in his published analysis of Lambeth water of May 10th, and in his analysis made for this report of Lambeth water of May 20th. The differences between the two are no greater than would be expected (without any allowance for experimental error) actually to exist between two samples of the same water taken at 10 days interval, the one from a (clean) cistern, the other from a main.

A third point of considerable interest is to be noticed. It has already been shown that the amount of nitric acid in a water as indicated by the indigo process is decreased by the addition of albumen to the water, and that the more albumen added the less nitric acid do we find. Dr. Frankland's method of estimating the amount of nitric acid is not, however, open to the same objection, for he found in sample NN, which contained albumen, almost as much nitric acid as the sample was polluted with, but Dr. Dupré with the indigo test only found a trace. It would therefore appear that the presence of albumen in the water interferes with the indigo test, and prevents it indicating the true amount of the nitric acid present.

Subjoined are notes by Dr. Frankland,* and some observations

* Dr. Frankland notes :—"Sample NN was clear at first, but soon became milky and deposited a sediment which contained moving and other organisms in great abundance and sparsely distributed fungoid growths. The microscope showed in this sediment crowds of motionless bacteria and large cylindrical cells filled with granular substance. These last were entirely different from any organisms I have ever before observed in water.

"Although it contained only a very moderate proportion of solid matters in solution and was very soft, it was so excessively polluted with highly nitrogenous organic matter as to infringe, both in respect of organic carbon and organic nitrogen, the somewhat lax standards of the Rivers Pollution Commissioners. It was therefore condemned by those standards as inadmissible into running water. This being the case, it was, of course, quite unfit for dietetic purposes, and would be condemned as a dangerous water.

"Sample OO contained about the same proportion of solids in solution as Thames water, and was of about the same degree of hardness, but it was polluted with very highly nitrogenous matter, contained a very large proportion of ammonia, and exhibited considerable evidence of previous animal contamination. I should condemn this water as quite unfit for dietetic purposes. It was the only sample which contained nitrites, but these were present in very minute quantity only, and no moving or other organisms were found in it.

"Samples PP and MM were very much alike, except that PP contained rather a large proportion of ammonia. They both contained moving organisms and a moderate amount of organic impurity, and with the exception of the ammonia in PP which, however, is not very material, and the highly nitrogenous character of the organic matter, there is nothing in these samples which would lead me to class them as inferior to the better sorts of Thames water delivered to consumers in London." [July 17, 1881.]

App. B. No. 1.

On Samples of Water purposely polluted with Excrements, etc.; by Dr. Cory.

by Dr. Dupré,* on the results of their analyses of the polluted waters.

Experiment XIV.

In experiment X. it was found, when intending to pass a polluted sample of water through a filter of sand, that only a very small portion of the polluted water did so pass, the rest remained in the filter. The present experiment was undertaken, therefore, to ascertain the conditions under which a polluted sample could be passed through a filter and collected. A filter was prepared by taking a drain pipe six inches in diameter and two feet long; its unflanged end was inserted into an earthenware funnel of suitable size, the funnel having been previously partially filled with pumice stone and tow, to prevent the sand being washed through. When this had been done the drain pipe was filled up to within $3\frac{1}{4}$ inches of the top not reckoning the flange, with clean dry sand; it took 10600 c.c. of sand to do this; 6000 c.c. of tap water were then poured into the filter, and the sand thereupon settled down $1\frac{1}{8}$ inches. In 16 minutes the water began to drip from the funnel, and in 24 hours from this time 2998 c.c. had passed, and the filter had ceased to drip. It was clear, therefore, that the filter retained 3002 c.c. of fluid. Next a solution of salt (NaCl) was prepared of such a strength that 1 c.c. contained ·01 grm. of chlorine; 10 c.c. of this solution were added to 1990 c.c. of tap water, which itself contained chlorine in the proportion of 1·4 grains per gallon; hence the proportion of chlorine in the sample would be 4·9 grains per gallon.

This sample was now poured into the saturated filter, which thereupon began to drip immediately, and in 40 minutes 1500 c.c. had passed; 70 c.c. of the last of this filtrate were taken and found to contain chlorine in the proportion 1·6 grains per gallon; the rest of it was returned to the filter. In another 15 minutes 850 c.c. more water had passed; 70 c.c. of the last flowing portions of this filtrate were taken and found to contain chlorine in the proportion of 1·8 grains per gallon; the rest of it was returned to the filter. In another 17 minutes 750 c.c. more water had passed, and 70 c.c. of the last flowing portions of this filtrate were taken and found to contain chlorine in the proportion of 4·2 grains per gallon. The rest was returned to the filter. After this the filter was left to stand for the night, and the filtrate that passed was collected. In the morning it was found that 1745 c.c. had passed, and it was ascertained that 70 c.c. taken from the 1745 c.c. contained Cl in the proportion of 4· grains per gallon. Some more tap water was then added to the filter, which began to drip immediately afterwards, and the first 70 c.c. that passed was found to contain Cl. in the proportion of only two grains per gallon.

---

* Dr. Dupré explains the large excess of "organic carbon" found by him over that found by Prof. Frankland by having, for the first time, in the above analyses, used sulphurous acid instead of phosphoric acid, for adding to the water under examination, and that he overlooked Prof. Frankland's direction, to boil the water for a short time after the addition of the sulphurous acid, in consequence of which omissions he says the organic carbon he found is too highly represented.

Dr. Dupré also directs attention to the amount and nature of the polluting matters being such as to bring out to the best advantage Prof. Frankland's process as contrasted with the albuminoid ammonia process. Granting this to be the case, yet it must not be forgotten that the polluting substances were of a very usual sort and that a previous knowledge of the amount and nature of the polluting material is seldom had by the analyst. At any rate it is certain that the aptitude of the pollution to find expression by one or another method was altogether undesigned.

From the above it is clear that the great bulk of the sample of water containing the chlorine began to pass after about 3000 c.c. of the water previously retained by the filter had passed, and that very little mixture of the waters in the filter took place, the one water only displacing the other.

Experiment XV.

On the 20th March two samples were prepared, QQ and RR. They were prepared as follows:—

The same filter was thoroughly washed by passing Lambeth water of the 20th March through it, and when this had been done three litres of Lambeth water of the 14th February were poured in; after this when three litres had passed it was considered that the water retained by the filter consisted mostly of Lambeth water of the 14th February. Next 1983 c.c. of Lambeth water of the 14th February, to which had been added 15 c.c. of salt solution (equivalent to 5·25 grains of chlorine per gallon) and 2 c.c. of egg albumen, were now poured in, and the next two litres of water that passed were collected for sample QQ. Two more litres of the Lambeth water were next added to the filter and the next litre of water that passed was returned to the filter, and the following two litres were collected for sample RR. It was observed in collecting this latter sample how very slowly the water passed through the filter. From the method used in preparing the samples it was anticipated that sample QQ would consist mainly of Lambeth water of the 14th February, and sample RR of the same Lambeth water, but containing a large percentage of the salt which had been added, and as much albumen as the filter would allow to pass. The following table gives the results of Dr. Dupré's analysis of these samples, to which has been added for the purpose of comparison the results of the analysis of Lambeth water of the 14th February, but which was made on the 15th of February, and not at the time when the above experiment was made.

	Lambeth water of 14th February from House Cistern, analysed 15th February.	QQ. (*See text.*) Two litres of Lambeth water of 14th February from House Cistern, kept in filled Winchester quart bottle, analysed March 21st. Passed through filter.	RR. (*See text.*) Mixture containing in gallon of Lambeth water of Feb. 14, 38·4 grains total solids, viz.: 19·6 solids of water, 10·15 solid dry albumen, 8·65 NaCl. Two litres of this mixture passed through filter and examined.
Appearance	Clear	Very slightly turbid	Very slightly turbid.
Colour	Rather deep brown	Pale brownish	Pale brownish.
Deposit	None	Slight trace	Slight trace.
Nitrous acid	None	None	None.
Phosphoric acid	Strong trace	Slight trace	Strong trace.
Colour of residue	Brownish	Yellowish brown	Yellowish brown.
Behaviour of residue on heating.		Blackens very perceptibly.	Much carbon separates, slight smell of burning nitrogenous matter.
	Grains per gallon.		
Oxygen absorbed from permanganate.	0·14	0·106	0·171
Total dry residue	19·6	20·02	29·96
Consisting of { Volatile salts	1·96	2·10	4·20
Consisting of { Fixed salts	17·64	17·92	25·76
Chlorine	1·11	1·07	5·01
Nitric acid	·53	0·62	0·89
Ammonia	·0014	0·0112	0·0112
Albuminoid ammonia	·0112	0·0084	0·0647

From the above analyses it would appear that the filter retained most of the albumen, but allowed the inorganic salts to pass. Indeed it acted as an imperfect dialyser, separating the colloid substances from the crystalloids.

Microscopic Observations.

In addition to the foregoing observations made on the microscopic appearances of liquids in the course of various experiments, Mr. Stewart has made some other notes and drawings on a number of purposely inoculated liquids of one and another kind; but hitherto without important affirmative result.

I now pass to consider what general conclusions appear to be justified by the foregoing experiences.

General Conclusions to be drawn from the above Analyses as to the Value of the different Methods usually employed for the estimation of the amount of Organic Matter contained in Water; namely,

(1.) The oxygen absorbed from permanganate of potash.
(2.) The albuminoid process of Messrs. Wanklyn and Chapman.
(3.) The estimation of nitric acid.
(4.) The processes for estimating the organic carbon and organic nitrogen.

*Firstly with regard to the permanganate process.**—This method as usually conducted and known as the Forchammer process is not satisfactory. Applied to the examination of waters polluted with differing amounts of the same organic material, it does indeed tell the direction of the difference and even give some indications of the relative amounts. But for the process to show as much as this, it is important that the circumstances of the several samples shall have been identical (*see*

* The following table has been drawn up to save the reader some references to the text of earlier analyses (A line among the figures signifies "no observation"):—

Analysis referred to.	Nature of Pollution.	Intentional pollution. Grains of stool per gallon.	Estimated amount of solid dry soluble matter. Grains per gallon.	Resulting increments, in grains per gallon. Of solid dry residue.	Of albuminoid ammonia.	Of oxygen absorbed from permanganate of potash.	Of chlorine.
Ex. i. -	Typhoid stool	1·75	·106	·0	·002	—	·0
Ex. v. -	Healthy stool	1·75	·106	·56	·0059	·1717	·0
Ex. i. -	Typhoid stool	3·5	·21	·28	·0048	—	·0
Ex. ii. -	Ditto - -	3·5	·21	·28	·0045	·1481	·0
Ex. iii. -	Ditto - -	3·5	·21	·28	·0021	·0970	·03
Ex. v. -	Healthy stool	3·5	·21	·84	·0216	·1533	·07
Dupré, P. -	Typhoid stool	3·5	·21	·56	·001	·0097	·0
Frankland	Ditto - -	3·5	·21	·392	—	—	−·07
Wanklyn -	Ditto - -	3·5	·21	—	·0014	—	·0
Ex. iii. -	Ditto - -	4·37	·267	·28	·002	·1678	·07
Ex. ii. -	Ditto - -	5·25	·32	·14	·0084	·1641	·0
Ex. vii. -	Ditto - -	7·	·427	·0	·0027	·0970	−·035
Ex. iii. -	Ditto - -	8·7	·533	·28	·0138	·1986	·07
Ex. vii. -	Ditto - -	14·	·85	·56	·0075	·0850	·0
Ex. x. -	Ditto - -	135·1	8·24	5·20	·0237	1·023	·0

analyses KK and LL) particularly that one shall not have been kept longer than the other (*see* experiments IV. and VI.). The Forchammer process does not give more than this indication of relative amount. The test affords no indication of the total amount of oxydizable material contained in the water and cannot therefore be employed in comparing water from different sources.

A parallelism has been pointed out, found in the examinations of the Thames waters, between the oxygen absorbed from permanganate of potash and the organic carbon as determined by the combustion process of Dr. Frankland, but it is certain this parallelism can only hold so long as the inorganic as well as the organic impurities contained in the water remain of the same kind varying only in quantity. But the process would appear to be capable of improvement, and I annex a paper by Dr. Dupré containing proposals for its better application in future.

Secondly, with regard to the albuminoid ammonia process of Messrs. Wanklyn and Chapman.—(*a.*) This again may be trusted to show which of two samples of water is the more polluted, when the polluting material contained in each is of the same kind; also in that case, and when the absolute amount of polluting material is not great, it is capable of determining the relative degree of pollution in a number of samples.*

(*b.*) But when the polluting material is in large absolute quantities a given difference in the extent of pollution is not indicated by corresponding difference in the yield of albuminoid ammonia. (*See* Table, page 154, note; and see details of experiments.)

(*c.*) Equal amounts of albuminoid ammonia may be furnished by extremely different quantities of nitrogenous polluting material, and conversely extremely different quantities of albuminoid ammonia may be furnished by one and the same quantity of nitrogenous polluting material; and this is the case even though the polluting substances differ no more inter se than one typhoid stool differs from another typhoid stool. When a typhoid stool is compared with a healthy stool obtained under somewhat similar conditions of diet, water polluted with the healthy stool yields to this process a larger amount of albuminoid ammonia than water polluted by the same quantity of typhoid stool. (Compare experiments I. and V.)

(*d.*) The classification of waters, given by Messrs. Wanklyn and Chapman on page 68 of their work on water analysis (5th edition) is calculated to mislead in a very dangerous way. "Drinking water," it is there stated, "falls into three classes according to the degree of organic purity," and class I. comprises "water of extraordinary organic purity "yielding from 0·00 up to 0·05 parts of albuminoid ammonia per "million." . . . . "Water of this class cannot be objected to "organically." Yet the pollution of a gallon of water by all the soluble and finer particulate matter from 3·5 grains of typhoid stool is represented in Mr. Wanklyn's own hands, by no greater increment than 0·02 part of albuminoid ammonia per million of water. (*See* experiment IX. and footnote.)

* It may be said, indeed, that Mr. Wanklyn does not profess more than this for his method. In an appendix to the fifth edition of his work on water analysis, commencing on page 156, he seeks to show how differently different organic nitrogenous substances behave when treated with a strong alkaline solution of permanganate of potass; some giving up the whole of their nitrogen as ammonia, some a half, one a third, another a quarter, and pure urea, he says, gives up none. This behaviour of urea has been the subject of two sub-experiments annexed to experiment IV. of this report, to which I would refer.

Thirdly, as respects the estimation of nitric acid.—Dr. Dupré has chiefly made use of the indigo process with this object. The results would seem to exhibit a reduction in the amount of nitric acid contained in the water, as a consequence of the addition to the water of such polluting materials as typhoid stool, urine, egg-albumen, and blood-serum. Comparison of the quantity of nitric acid detected by Dr. Dupré, and that discovered by the method employed by Dr. Frankland, gives a preference to the latter. Dr. Frankland's process decomposes nitric acid into nitric oxide, and determines its amount by the quantity of gas evolved.

*As regards, fourthly, the processes for determining organic carbon and organic nitrogen,** it is to be observed in the first place that they differ from all three of the other methods that have been put to the proof. Whereas those methods base their claim to consideration principally upon their furnishing means of recognising the greater or less relative quantity of organic material present in water, and proceed upon some broad general assumptions about the character of that material; the following processes claim to tell the absolute quantity of carbon and nitrogen contained in the organic matters of water; and, of course, therefore, when the composition of an organic substance is known they should be able to tell the actual amount of that substance that has been added to a given quantity of water.

The question to be considered for these processes, then, is how far do they really achieve their professions, and with what degree of confidence may we go on to reason from the actual quantities of carbon and of nitrogen, from the relations between the two elements, and so forth.

We will first consider the results of the analysis of sample NN, in experiment XIII. This consisted of distilled water, to a gallon of which

---

* Dr. Dupré's method of determining the amount of organic carbon consists in evaporating a sufficient quantity of the water acidulated with phosphoric acid to dryness in a silver foil vessel. The vessel is then crumpled up and transferred to a combustion tube. The tube is then filled up with granulated cupric oxide and heated to redness while a stream of oxygen is transmitted through it. The issuing gases are conveyed into a Pettenkofer's tube charged with a perfectly clear solution of baryta water. In this way all the "organic carbon" is given off in the form of carbonic acid and the latter combining with baryta is precipitated as carbonate of baryta. The carbonate of baryta is then collected on a filter and dissolved in dilute hydrochloric acid. Dilute sulphuric acid is then added to the solution and the resulting sulphate of baryta is dried and weighed. The result divided by 19·4 gives the quantity of organic carbon present.

To determine the amount of "organic nitrogen" a separate quantity of the water is taken and evaporated to a small bulk; a sufficient quantity of sulphurous acid and ferrous chloride is then added to decompose nitrates, and the evaporation is then completed. The residue is transferred to a silver boat and mixed with caustic soda. The boat is then introduced into a combustion tube, which is heated to redness, while a stream of hydrogen gas is passed through it. The resulting gases are then conveyed into an absorption apparatus, charged with dilute hydrochloric acid, which retains the ammonia as chloride. The amount of ammonia is then estimated by Nessler's test.

Dr. Frankland's method of determining the organic carbon and organic nitrogen consists in evaporating a litre of the water acidulated with sulphurous acid to dryness. The residue is transferred to a combustion tube which is then filled up with cupric oxide. The tube is next exhausted by means of a form of Sprengel's pump and when the exhaustion is complete the tube is heated to redness. The resulting gases, consisting of carbonic acid, nitrogen, and perhaps nitric oxide are conveyed into a gas-analysis apparatus where their aggregate volume is determined over mercury. After this has been done the gases are brought into contact with a few drops of a strong solution of caustic potass; by which means the carbonic acid is absorbed. The volume of gas which now mainly consists of nitrogen is again noted. Means are next taken to ascertain the volume of nitric oxide, if any is present, and from the data thus obtained the amounts of organic carbon and nitrogen are calculated.

3·595 grains of certain inorganic salts and 5·075 grains of dried egg-albumen had been added. As both Dr. Dupré and Dr. Frankland give the total solid residue at 7·84 grains per gallon, it is probable that the difference between this amount and the total 8·67 grains known to have been added is a real difference, due to subsidence of the delicate membranes, in the meshes of which the albumen is contained in eggs. If so, there remained 4·245 grains of dry albumen to account for. Now, on Lieberkuhn's formula for albumen ($HNaC_{72}H_{110}N_{18}SO_{22}H_2O$) every 1116 parts by weight of carbon and nitrogen together represent 1652 parts by weight of dry albumen. Wherefore, Dr. Dupré's total of 3·219 grains of carbon and nitrogen together would count for 4·76 grains of albumen per gallon, and Dr. Frankland's 2·0454 grains of carbon and nitrogen together would count for 3·03 grains of albumen. Dr. Dupré's process therefore would seem to give the amount of albumen as rather more, and Dr. Frankland's to give it as rather less, than it is known to have been.

Further, on the same formula, the ratio by weight of carbon to nitrogen contained in albumen is as 24 to 7. By Dr. Dupré's analysis, the ratio of organic carbon to organic nitrogen in sample NN was as 24 to 5·2, and by Dr. Frankland's analysis the ratio between the same element in the same sample was as 24 to 7·5. It would appear, therefore, that the organic carbon is somewhat over-estimated by Dr. Dupré's analysis.

To pass to the analysis of sample OO. This consisted of Lambeth water polluted with urine of specific gravity 1028, in the proportion of 5 c.c. in a litre of water. This would be (on the customary method of reckoning the solids in urine) equal to 2·347 grains of urinary solids in a gallon. The increment of impurity resulting from this pollution was not shown to Dr. Dupré by any increase of total solids in the water, but (besides being shown as ammonia) it was evidenced by ·448 gr. increment of organic carbon and ·527 grain increment of organic nitrogen. Dr. Frankland found the evidences of the same amount of the same impurity to consist in an increase of total solids by 1·008 grains, an increase of organic carbon by ·1764 grain, and of organic nitrogen by ·4305 grain.

On these results it is to be observed, first, that it was not to be anticipated that the total solids should be discovered by the usual process, since that involved the evaporating of the sample and much of the urea of the added urine must have been lost as ammonia; especially would this be likely to have happened if the water was kept a day or two to allow of settling before being analysed; but the slight reduction of total solids reported by Dr. Dupré in the polluted as compared with the unpolluted sample of water is not explained by this consideration. Secondly, it is noteworthy that the increase of total solids detected by Dr. Frankland corresponds fairly with the amount that would be calculated from the increments of organic carbon and organic nitrogen as discovered by his process, if the total solids be reckoned as urea [$(·1764 + ·4305) \times 1·5 = ·9103$, which is not greatly different from 1·006]. The increase of these two elements reported by Dr. Dupré is larger, but there is no increment of total solids with which to compare it. Then, thirdly, as regards the ratio between organic carbon and organic nitrogen:—In urea it should be as 3 to 7, and it would not be very dissimilar in the case of the total solids of the urine. Dr. Frankland's process showed the increments of organic carbon to hold to the increment of organic nitrogen the ratio of 3 to 7·3; but this ratio as deduced from the increments on Dr. Dupré's process was as 3 to 3·52. In analysis OO, therefore, equally with analysis NN, it would

App. B. No. 1.

On Samples of Water purposely polluted with Excrements, etc.; by Dr. Cory.

appear that Dr. Dupré's process gives an erroneous ratio of organic carbon to organic nitrogen by over-estimating the former.

It would not be wise to generalise much from the results of these two analyses; but, having regard to the intentions of the method, to deal with the final elements of organic matter, it is probably permissible to form a judgment on it, without any great variety of experiments. And the impression conveyed to me by the results of these processes for the determination of organic carbon and organic nitrogen is to prefer them to the processes which aim at bringing into simpler combinations the various elements of organic substances, and at deducing the quantities of these substances from the quantity, actual or inferred, of those combinations. Particularly, I am disposed to esteem the process of determining organic nitrogen as employed by Dr. Dupré, and the process for estimating the organic carbon and organic nitrogen made use of by Dr. Frankland.

APPENDED NOTES.

I append notes by Mr. Stewart and Dr. Dupré of the methods severally employed by them.

(1.) Note by Mr. Stewart on Methods of Microscopical Examination.
(2.) Sketch by Dr. Dupré of his Methods of Analysis.
(3.) Observations by Dr. Dupré on the Permanganate Process.

(1.) Microscopical Method of Examination of the Water.

The samples of water were mostly received in Winchester quart. These were allowed to stand for six hours to allow of any deposit settling. Two-thirds of the water was then decanted off with a siphon, the remainder was then well shaken to re-mix the deposit, then poured into a depositing glass and covered over. After standing six hours its appearance was noted; the water and sediment, if any, then examined with the microscope, first with the power of 350 diam., and then with others ranging to 1,250 diam., the nature and amount of solid matter being then recorded.

Should any further researches be contemplated in the direction of the foregoing, the following points have suggested themselves as of general interest, and bearing on some of the questions at issue. The mixture with recently distilled water of a known quantity of different fresh organic substances, one sample wet as expressed, another the same filtered, another of an equal quantity dried; an equal temperature being maintained, a daily record of the changes, microscopic and otherwise, should be kept. The influence on the development of organisms, of certain gasses, such, namely, as they might be exposed to in nature, would prove of interest.

Some good might, perhaps, result by experiments to determine what, if any, injurious effect would be produced on animals by their taking water in which different putrefactive changes and various associated organisms might be present, although one is met by the difficulty that many substances highly injurious to one animal are innocuous to another; while experiments on criminals (man being probably more prone to enteric and other disturbances from such causes) would probably be considered unjustifiable.

As regards the probability of the microscope revealing the presence in water of special organisms which are the real agents in producing certain diseases, this, of course, is possible; but organisms apparently identical may really have a subtle difference which the microscope cannot show, and which rather reveals itself by its effect than by visible structure.

(2.) Sketch by Dr. Dupré of the Methods of Analysis employed.

The chief object of inquiry being, for the present at least, to discover how far chemical analysis, as now generally practised, would be able to throw light on the special nature of the pollution suffered by a water, no attempt was made to discover new methods. All the analyses were therefore carried out precisely in the manner ordinary water analyses are conducted by myself, with the single exception of the method employed for estimating the amount of oxygen absorbed from permanganate, which was changed to a different one after the first three analyses had been made.

In every case the water was allowed to stand at rest over night and the clear water only taken for analysis.

Nitrous Acid.—This was only tested for qualitatively by means of starch, iodide of potassium and diluted sulphuric acid. If, after standing for five minutes, no blue colour was produced in a water to which the above reagents had been added, nitrous acid was presumed to be absent. If a blue colouration made its appearance its lesser or greater degree of intensity, depending on the amount of nitrous acid present, is noted as: minute trace, trace, strong trace, much &c., &c. of nitrous acid.

Phosphoric Acid.—This also was only tested for qualitatively, and a similar rough scale as that given under nitrous acid is used to express variations in amount observed. In every case the residue left by ¼ litre water, used for estimating the total dry residue, &c. &c., was used for the test, which consisted in warming the solution of the residue in nitric acid after filtration, with a strongly acidified solution of molybdate of ammonia.

Oxygen absorbed.—A standard solution of permanganate of potassium containing 10 per cent. of caustic soda was added in slight excess to ¼ litre of the water, and the mixture heated in a water bath to the boiling temperature for the space of three hours. After the lapse of that time the still remaining permanganate is estimated, from which the amount of permanganate decolourized, and consequently the amount of oxygen absorbed is obtained.

Total dry Residue and volatile Matter.—One-fourth litre of water is evaporated in a platinum dish on a water bath; the residue is dried at 120° C. and weighed; it is then ignited, moistened with carbonate of ammonia, to restore the carbonic acid which may have been expelled during ignition, again dried at 120° C. and re-weighed. The second weighing gives the fixed salts, the difference between this and the first volatile matter. The colour of the residue is also noted as well as its appearance during ignition, and the odour evolved during the same.

Chlorine.—One hundred cubic centimetres of water are carefully evaporated to about 20 c.c., and in these the chlorine is estimated by standard nitrate of silver (1 c.c. indicating 0·001 grm. chlorine), using chromate of potassium as an indicator.

Nitric Acid.—Twenty-five cubic centimetres of water are mixed with 50 c.c. of strong pure sulphuric acid and a dilute standard solution of indigo carmine is run into the hot mixture till the mixture assumes the faintest perceptible, permanent, blue tint.

Ammonia and Albuminoid Ammonia.—These are estimated by what is known as Wanklyn's process; ½ litre of water, placed in a retort connected with a condenser, is rendered alkaline by carbonate of soda and 200 c.c. are distilled over. A freshly boiled, strongly alkaline solution of permanganate of potassium is then added, and distillation continued. Two hundred cubic centimetres more are distilled, and, of course, separately collected. In 100 c.c. of each distillate the ammonia is now estimated by Nessler's reagent, the first distillate containing the free (or saline), the second the albuminoid (organic) ammonia. In case the second distillate contained much ammonia the distillation was continued, and a second or even third portion of 200 c.c., or 600 c.c. in all, after the addition of the permanganate, distilled. This could, of course, only be done by adding some more water to the contents of the retort (the water for this was first boiled for some time with alkaline permangate). In most cases

it was found unnecessary to distill more than 200 c.c. after the addition of the permanganate; but, on the other hand, in all the cases in which urine had been added to the water, even 600 c.c. of distillate did not contain all the albuminoid ammonia that could be evolved. In these cases, indeed, it seemed almost impossible to bring the action to an end, and the distillation was stopped after 600 c.c. had been collected. Some albuminoid ammonia was thus, no doubt, left undetermined; but as in all these cases the amount collected was far beyond the limits which could be tolerated in drinking water, it was not thought necessary to carry the evolution of albuminoid ammonia to the end, which would have involved a day's distillation, or even longer.*

Organic Carbon and Nitrogen.—These were estimated in the three cases given in the residue from ¼ litre water by the methods of Dittmar, and of Dupré, and Halke, respectively; the water having been evaporated, with the addition of sulphurous acid, under a glass shade as recommended by Dr. Frankland. For the estimation of nitrogen (Dittmar's method) the water residue is burnt with baryta and caustic soda in a current of hydrogen; the ammonia produced is collected in very dilute hydrochloric acid, and estimated by Nessler's test. To estimate the carbon, the residue is burnt in a current of oxygen, and the carbonic acid produced collected in baryta water. The carbonate of baryta formed is next collected, washed and weighed, in the form of sulphate; 0·001 grm. carbon yields 0·0195 grm. sulphate of baryta.

(3.) Note of Experiments undertaken by Dr. Dupré to test the Value of the Methods by which the Quantity of Organic Matter in a Water is estimated by the Amount of Oxygen absorbed from Permanganate of Potash.

Oxygen absorbed from Permanganate.—The method adopted in the former investigation not having yielded perfectly satisfactory results the following modifications were introduced:—

One quarter litre (¼ litre) of the water is measured into a perfectly clean 12-oz. stoppered bottle,† the temperature of the water is raised to 80° F. by immersing the bottle in warm water, 10 cub. cent. of diluted sulphuric acid (1 vol. acid to 3 vol. of distilled water) and 10 cub. cent. of standard permanganate solution (·395 parts of pure potassium permanganate in 1,000 of solution, each cub. cent. contains 0·0001 gramme of available oxygen) are added, the bottle is stoppered, and kept for four hours steadily at the temperature of 80° F. At the end of that time the permanganate still remaining undecomposed is estimated by iodide of potassium and hyposulphite of sodium, and the amount found deducted from that added gives of course the amount decomposed by the water. If in the course of the four hours the pink colour of the water in the bottle is either discharged or even materially reduced another 10 cub. cent. of

* On this point, however, it is to be observed that Mr. Wanklyn's directions are explicit. After mention of precautions to be taken "in the analysis of very bad water," (page 39, 5th edition, 1879), he continues, "the destillation must be continued until 50 c.c. of destillate have "come over, and this must be collected in a cylinder for Nesslerising. A second c.c. must be "collected in another Nessler cylinder, and a third 50 c.c. must be collected; *and this having "been done the destillation may be stopped, and the apparatus left standing until it is "required for another analysis.*" It is true that, in an appended note, when describing how 100 c.c. of water may be made to suffice for the purposes of analysis equally with a larger quantity, Mr. Wanklyn's instructions may be read (pages 51-52) as requiring the process to be further continued. Operating with this small quantity of water, he first distils over 10 c.c., which he submits to the Nesslerising process. "That having been done, 30 c.c. more are to be "distilled off, and either Nesslerised or thrown away." . . "At this stage the distillation is "to be interrupted, and 10 c.c. of the solution of potash and permanganate of potash are to be "poured into the retort, *and the operation continued so long as 10 c.c. of distillate shows a "sign of ammonia.*" And again, in a further appendix (page 157), dealing with the ammonia evolved by alkaline permanganate acting on Organic Nitrogenous Compounds, Mr. Wanklyn tells how "the distillation was continued until the evolution of ammonia ceased or became very trifling." [The italics are my own.—R. C.]

† These bottles are best cleaned and kept clean in the following way. The bottle having been carefully washed with acid and water, is filled with distilled water strongly acidified with sulphuric acid. Some permanganate solution is now added sufficient to strongly tint the water, the stopper is put in, and the bottle kept in a warm place until used; it is then only necessary to empty it, rinse it with a little strong hydrochloric acid, and wash it well with tap water, when it is ready for use.

standard permanganate must be added, and this has to be repeated if necessary so as to keep the water always strongly tinted.

In the course of the investigation the following points were more especially investigated:—

1st. Whether at a temperature of 80° F. the acidulated permanganate solution did suffer any appreciable amount of decomposition independently of the presence of organic matter in the water. Whether in fact it suffered any spontaneous decomposition.

2nd. Whether variations of temperature materially affected the proportions of oxygen absorbed.

3rd. Whether variations in the amount of permanganate used affected the result.

4th. Whether the substitution of phosphoric for sulphuric acid might prove beneficial.

5th. Several minor points connected with the carrying out of the experiments were investigated.

In regard to the first point, it was found that with a pure water no appreciable amount of of permanganate suffered decomposition. Thus, in several samples of Trafalgar Square water taken during February 1881, the amount of oxygen absorbed during four hours at 34° F. was found to be 0·0017 grain per gallon, while at 80° F. it amounted to 0·0036 grain. Now, under the conditions of the experiment 0·1 cub. cent. permanganate solution is equivalent to 0·0028 grain of oxygen absorbed per gallon, and the difference above found between the absorption at 34° F. and 80° F. is therefore fairly within the limits of experimental error; in it, moreover, is included the oxygen absorbed by the minute trace of organic matter contained even in so pure a water. The experiment has been repeated at least 10 times with a like result. We are therefore justified in concluding that in a pure water no appreciable proportion of permanganate suffers spontaneous decomposition under the conditions of the experiment as above described.

The method adopted by some chemists of starting a blank experiment with distilled water simultaneously with the experiment on the water under examination, is therefore entirely unnecessary and may even be greatly misleading.

In regard to the second point, influence of variations of temperature, it was found as might have been expected from the result just given, that in a comparatively speaking pure water even wide variations of temperature have little or no influence on the result. Thus in the case of Trafalgar Square water taken during February 1881, the amount of oxygen absorbed per gallon was found to be in four hours:—

At 34° F. - - - 0·0017 grain,
At 62° F. - - - 0·0045 ,,
At 80° F. - - - 0·0036 ,,

and with water from the same source drawn in March 1881 the oxygen absorbed per gallon was found to be in four hours—

At 80° F. - - - - 0·0115 grain,
At 100° F. - - - 0·0129 ,,

showing that even at 100° F. the amount of oxygen absorbed is not materially greater than at the lower temperature, although in this last case the water was not quite so pure as in the first.

The case is, however, entirely altered if a less pure water has to be dealt with. Thus, in the case of a water drawn from a main of the Chelsea Company the oxygen absorbed in four hours—

At 35°·6 F. amounted to 0·0526 grain per gallon.
At 80° F. ,, 0·0717 ,,

a difference about ten times greater than in the first case.

A well water from Farnborough absorbed in four hours—

At 32° F. 0·0395 grain oxygen per gallon.
At 60° F. 0·0554 ,, ,,
At 80° F. 0·0613 ,, ,,

It is thus evident that temperature has a most material influence on the result in all but the purest waters, and it becomes, therefore, of importance, in order to obtain reliable comparative results, to keep the

waters to be tested closely to the same temperature in every experiment. A series of experiments in which even so small a variation as 10° F., a variation which is certain to be exceeded unless special precautions are adopted, will thus yield results of, comparatively speaking, little value.

The temperature of 80° F. has been chosen, as it is one which, in England at least, can always be obtained without the necessity of adopting means for cooling, which are far more difficult to carry out successfully than heating.

Some experiments have been undertaken for the purpose of finding out to what extent and in what direction variations in the character of the organic matter contained in the water, whether of animal or vegetable origin for example, influenced the amount of oxygen absorbed at different temperatures. The results so far obtained, although they seem to indicate that the more readily oxydisable matters are oxydised at the lower temperature in far greater proportion, compared with their oxidation at the higher temperature, than is the case with more stable organic matter, yet the experiments are not sufficiently numerous to warrant any general conclusions to be drawn.

The same observations may be made with regard to variation of oxidation in varying times. Here also it seems likely that valuable information in regard to the nature of the organic matter contained in a water may be gained by observing the amount of oxygen absorbed in different times; but here also many more experiments will have to be made before fairly sound conclusions can be arrived at.

Here it may be sufficient to observe that in most cases oxidation is more or less rapid at first, gradually becoming slower and slower. With very pure waters, or at low temperatures, the limit of possible oxidation is reached sooner than with impure waters or at higher temperatures. Thus, with a sample of Trafalgar Square water the amount of oxygen absorbed was—

At 34° F., in 3 hours, 0·0017 grain per gall.
,, ,, 4 ,, 0·0017 ,,
,, 80° F., ,, 4 ,, 0·0045 ,,

In another sample of this water the oxygen absorbed was—

At 100° F., in 1 hour, 0·0073 grain per gall.
,, 100° F., ,, 3 hours, 0·0115 ,,
,, 100° F., ,, 4 ,, 0·0129 ,,
,, 80° F., ,, 4 ,, 0·0115 ,,

In a Chelsea Company water the oxygen absorbed was found to be—

At 53°·6 F., in 3 hours, 0·0526 grain per gall.
,, 53°·6 F., ,, 4 ,, 0·0526 ,,
,, 80° F., ,, 3 ,, 0·0652 ,,
,, 80° F., ,, 4 ,, 0·0717 ,,

Or again, in a Chelsea water taken August 9th, it amounted—

At 80° F., in ¼ hour, to 0·0196 grain per gall.
,, 80° F., ,, ½ ,, ,, 0·0252 ,,
,, 80° F., ,, 4 hours, ,, 0·0560 ,,

Chelsea water, taken September 12th—

At 80° F., in ¼ hour, 0·0488 grain per gall.
,, 80° F. ,, 4 hours, 0·0868 ,,

Chelsea water, taken October 13th—

At 80° F., in ½ hour, 0·0406 grain per gall.
,, 80° F., ,, 4 hours, 0·0784 ,,

Trafalgar Square water, with 2·27 grains of gelatine dissolved in 1 gall. water—

At 80° F., in ½ hour, 0·0168 grain per gall.
,, 80° F., ,, 4 hours, 0·0364 ,,

the water by itself absorbing only 0·010 grain per gallon in four hours.

Trafalgar Square water, with 35 grains fresh urine added per gallon—

At 80° F., in ½ hour, 0·056 grain per gall.
,, 80° F., ,, 4 hours, 0·064 ,,

One great difficulty in determining the nature of the organic impurity ntained in a water appears to be the action of the oxygen dissolved in

the water, or other agencies which in time reduce apparently all kinds of organic matter to a more or less uniformity.

In regard to the third point, it appears that in moderately pure water at all events variations in the amount of permanganate taken do not very materially affect the result. Thus, in the case of Trafalgar Square water, the amount of oxygen absorbed in four hours per gallon was—

When 10 c.c. permanganate were taken, 0·009 grain per gall.
" 20 " " " 0·010 "

With a less pure water the difference is greater, but is still slight. A sample of Chelsea water, to which a very little blood serum had been added, absorbed—

When 10 c.c. permanganate were taken, 0·115 grain per gall.
" 20 " " " 0·120 "

4th. If, instead of using sulphuric acid for acidifying the water, phosphoric acid in equivalent quantity is employed, the differences remain substantially the same, but the total amount of oxygen absorbed becomes considerably less; thus in the case of the two waters just given, in the case of the purer water the absorption amounted—

When 10 c.c. permanganate were taken, to 0·0078 grain per gall.
" 20 " " " 0·0078 "

With the impure water—

When 10 c.c. permanganate were taken, to 0·091 grain per gall.
" 20 " " " 0·099 "

On account of this diminished absorption of oxygen it does not appear advisable to substitute phosphoric for sulphuric acid, in spite of the fact that the titration of the liberated iodine is decidedly sharper than when sulphuric acid is used.

Among other points investigated it may be mentioned that the nature of the vessel in which the final titration of iodine (to estimate the proportion of permanganate remaining) takes place is by no means without influence.

Thus, using an open moderately wide beaker, 10 c.c. permanganate liberated an amount of iodine which, when titrated at once and rapidly, required 11·3, 11·3, 11·25, 11·2 c.c. hyposulphite solution (in the first two cases phosphoric, in the last two sulphuric acid was used), while when half an hour was allowed to elapse 10·9 c.c. of hypo only were necessary. Or again, if instead of running the hyposulphite solution into the beaker as rapidly as possible, it was allowed to run in drop by drop, so that the titration occupied about 10 minutes altogether, 10·9 c.c. of hyposulphite were used in order to complete the reaction. It is thus obvious that a serious loss of iodine is suffered in the open beaker unless the titration is performed with great rapidity.

This loss is, however, avoided by taking the narrow-mouthed stoppered bottles above described in place of the beaker. It was then found that using phosphoric acid 11·2, 11·2, and 11·25 c.c. of hyposulphite were required when the titration was effected at once in half an hour, or drop by drop in 10 minutes. The corresponding figures with sulphuric in place of the phosphoric acid were 11·3, 11·35, and 11·25 respectively.

Finally, a great many experiments were made in order to observe the effect produced by boiling the water either by itself or with the addition of 10 c.c. of sulphuric acid per quarter litre on the amount of oxygen absorbed. The experiments are not sufficiently complete to warrant any general conclusion, but some of the points observed are nevertheless of interest even now.

Thus it was found that mere boiling of the water resulted, in some cases, in an increased absorption of oxygen. Three portions were taken of ¼, ½, and ¾ litres respectively. In the first the oxygen absorbed was estimated as usual, the second and third were each boiled briskly in a flask until both were reduced to a quarter litre, when the oxygen was also estimated. The result was, calculating in each case on a gallon of water, an absorption of oxygen—

In the first case of - - 0·0865 grain.
" second " - - 0·0894 "
" third " - - 0·0953 "

Or again, if instead of boiling down the water in the flasks, these were simply heated in a water bath, the necks meanwhile being closed by a glass marble, the increased absorption was still observable. Thus—

Chelsea water taken direct absorbed 0·0792 grain per gallon.
Heated for one hour - - 0·0834 ,,
Lambeth water taken direct absorbed 0·01156 ,,
Heated one hour - - - 0·01212 ,,

If instead of heating the water by itself it is heated after the addition of 10 c.c. sulphuric acid to the ½ litre the effect is, in many cases, even more marked. It is best to actually boil the water in the flask, keeping a glass marble on it, and before adding the permanganate to add a sufficient amount of pure water to restore the original bulk. It is also necessary to cool the water to 80° F. before adding the permanganate.

Chelsea water taken August 9th direct absorbed 0·0560 grain oxygen in four hours.

Boiled with acid one hour absorbed 0·0616 grain oxygen in four hours.

Chelsea water taken September 12th direct absorbed 0·0868 grain oxygen in four hours.

Boiled one hour with acid absorbed 0·1084 grain oxygenlin four hours.

On the other hand in the case of very pure water the oxygen absorbed is practically unaffected by boiling with acid.

Trafalgar Square water direct absorbed 0·0098 grain per gallon.
Boiled one hour with acid ,, 0·0100 ,,
Derby water direct - ,, 0·0123 ,,
Boiled one hour with acid ,, 0·0134 ,,

Occasionally in the case of impure waters containing a large amount of nitric acid less oxygen is absorbed after than before boiling. No doubt a considerable amount of oxydation is in these waters effected by the nitric acid liberated by the sulphuric acid at a boiling temperature.

A number of samples of water containing various substances in solution have also been examined by the method just described, and some very interesting results obtained.

Trafalgar Square water was used in every case, and the absorption of oxygen due to the water used may be taken at 0·008 grain per gallon either before or after boiling. By subtracting this amount from the amount found to be absorbed that portion when taken up by the substance dissolved is obtained.

Trafalgar Square water containing 7 grains of pure cane sugar per gallon taken direct, the oxygen absorbed was in four hours - - 0·059 grain per gall.
After boiling one hour with acid, oxygen absorbed in four hours - - - 0·630 ,,

Trafalgar Square water containing 1 grain of pure cane sugar per gallon taken direct, oxygen absorbed in four hours - - 0·0171 ,,
After boiling one hour with acid, oxygen absorbed in four hours - - - 0·1602 ,,

Trafalgar Square water containing 0·1 grain of pure cane sugar per gallon taken direct, oxygen absorbed in four hours - - 0·0090 ,,
After boiling one hour with acid, oxygen absorbed in four hours - - - 0·0160 ,,

Trafalgar Square water with 2·27 grains of starch (boiled into a paste previously) per gallon taken direct, oxygen absorbed in four hours - - - - - 0·008 ,,
After boiling for one hour with acid, oxygen absorbed in four hours - - 0·0199 ,,

Trafalgar Square water with 0·22 grain dry albumen dissolved per gallon taken direct, oxygen absorbed in four hours - - 0·014 ,,
After boiling with acid one hour, oxygen absorbed in four hours - - - 0·0630 ,,

Trafalgar Square water with 2·27 grains dry gelatine per gallon of water taken direct, oxygen absorbed in four hours - -	0·0364	grain per gall.
After boiling with acid one hour, oxygen absorbed in four hours - - -	0·0392	,,
Trafalgar Square water with 35 grains of fresh urine per gallon taken direct, oxygen absorbed in four hours - - - -	0·064	,,
After boiling one hour with acid, oxygen absorbed in four hours - - -	0·092	,,
Trafalgar Square water with 70 grains of urine per gallon taken direct, oxygen absorbed in four hours - - - - -	0·174	,,
After boiling one hour with acid, oxygen absorbed in four hours - - -	0·191	,,
Same water nine days later, taken direct, oxygen absorbed in four hours - -	0·087	,,

It will be observed that in some cases, notably in that of cane sugar, the amount of oxygen absorbed is greatly increased by previously boiling the water with diluted acid, and it is not unlikely that such a process will enable us greatly to extend our insight into the character of the organic matter contained in potable water. But more experiments are required. I may, however, mention that in the few cases in which I have been so far able to apply this process to waters taken from the same source at different times, I have noticed that an improvement in the general character of the water was accompanied by a less difference between the oxygen absorbed before and after boiling with acid. A small difference in the amounts thus absorbed may therefore apparently be taken as a favourable indication.

A number of experiments were also undertaken to test the effect of boiling the water with a solution of caustic potash equivalent in strength to the acid used. It was found, however, that even in the purest water the large amount of sulphate of potash produced by adding the necessary excess of sulphuric acid prior to the treatment with permanganate so greatly affected the stability of the permanganate as to render the process illusory.

A. Dupré.

Westminster Hospital, October 28th, 1881.

[It will be observed that Dr. Dupré throughout this note refers to differences between small amounts as being less important than differences between larger amounts, and this although the proportional differences are greater in the case of the smaller amounts. Thus he regards the difference between 17, 45, and 36 as being of little importance if the figures occur in the third and fourth place of decimals, while he attaches great significance to the difference between 39, 55, and 61 when the figures are found in the second and third place of decimals. The question is of the limits of experimental error; and on this point Dr. Dupré's judgment is entitled to all respect. Yet I think it must remain an open question whether variations of temperature operate so diversely as he supposes in the case of acid permanganate acting on purer and less pure waters respectively. —R. C.]

No. 2.

On the Relation of Pathogenic to Septic Bacteria; by Dr. Klein.

On the Relation of Pathogenic to Septic Bacteria, as illustrated by Anthrax Cultivations; by E. Klein, M.D., F.R.S.

The research, of which in the following report I propose to give the first instalment, had for its object, first, to investigate whether and how far the bacillus anthracis undergoes any change, morphologically and physiologically, when cultivated artificially; and secondly, whether ordinary bacteria of putrefaction and septic fermentations can by artificial cultivations be so modified as when introduced into the body of an animal to be productive of disease, that is to say, whether it is possible for an innocuous saprophyte to assume the properties of an obnoxious pathogenic organism.

Bacteria of putrefaction,

It is well known that bacteria of ordinary putrefaction may be introduced, either by ingestion with the food into the alimentary canal, or by inoculation into the skin, the mucous membranes, the subcutaneous or submucous tissue, or by direct injection into the vascular system, without there being produced in the animal experimented upon any appreciable disorder, that could be directly brought into connexion with the bacteria, provided that these latter be introduced in small quantities only. Large quantities, on the other hand, are productive of putrid intoxication, not so much on account of the presence of bacteria as on account of the now well known and generally accepted chemical putrid poison of Panum, Bergmann, and others.

and of disease,

It is equally well known that pathogenic bacteria prove their efficacy when introduced in minimal quantities, for it is essential to their character, to find in the animal organism a suitable soil for multiplication and by their increase in numbers to produce directly or indirectly a definite disorder in the animal economy.

respective behaviour in animal organism.

In order, then, to investigate whether saprophytic bacteria have assumed the properties of pathogenic organisms, it is necessary to bear in mind that they must be expected to show these properties after their introduction in minimal quantities into the animal organism; that is to say, they must be capable to resist and overcome the effects of the healthy tissues,—effects proving invariably deleterious to ordinary saprophytic bacteria,—and having done so, of starting a definite disorder in the tissue.

It will be admitted, I presume, that it is not necessary that the disorder be of a general nature; in some well-established instances, such as anthrax, febris recurrens, pneumo-enteritis of the pig, the malignant œdema (Koch), a general disorder ensues on the introduction of the pathogenic organism, but in other instances, such as the actinomycosis in cattle and man, known through the researches of Bollinger, Jahn, Israel, Ponfick, the effect of the invasion by the actinomyces is at first, at any rate, of a purely local nature, being generally limited to the lungs; similarly the introduction of tubercular virus into the anterior chamber of the eye is followed by an eruption of tubercles in the iris (Cohnheim and Salomonsen), and of the same character is the pulmonary tuberculosis occurring in dogs after inhalation (Tappeiner) of the tubercular virus. The malignant ulceration in mice (Koch) is in the same way at first a purely local effect of the introduction of a pathogenic organism. And it will be necessary to postulate at least this of a would-be

On the Relation of Pathogenic to Septic Bacteria by Dr. Klein.

Question of transmutation: Recent researches.

pathogenic organism, viz., that its effect after its introduction into an animal should be local, but need not be so if general.

As is well known, Professor v. Nägeli is a firm advocate of the "sporting" of harmless saprophytes, they becoming converted under certain conditions into pathogenic organisms. But, on the other hand, Prof. v. Nägeli also maintains that pathogenic bacteria may become converted into harmless saprophytes. His views are stated with great clearness in his work, Die niederen Pilze, &c. Munich, 1877. From many years' studies, carried on with patience, and after a strictly experimental method, he arrived at these important conclusions.

Prof. v. Nägeli makes the very widest allowance for bacteria, inasmuch as a harmless form when brought under suitable conditions may become the origin of an infectious disease, may through generations retain this power, and when again placed under different conditions, may change into an inactive form.

Dr. Hans Buchner, a pupil of v. Nägeli, and working under this latter's directions, put these general statements to a special test, and succeeded, or maintains to have succeeded, in confirming them. He claims to have succeeded in changing, by successive artificial cultivations under constantly varying conditions, the bacillus anthracis, of previously deadly power, into a perfectly inactive and harmless bacillus, which in morphological respects appeared then identical with the motile bacillus subtilis (Cohn) of hay infusion. But he also thinks he has succeeded, what is of even greater and more fearful consequence, in transforming through artificial cultivations under ever varying conditions, the notoriously harmless bacillus subtilis of hay infusion into deadly bacillus anthracis.

Dr. Buchner's paper, Ueber d. exper. Erzeugung d. Milzbrandcontag. aus d. Heupilzen . . ., which gives the results of a very large number of observations, is published in the Sitzungsb. d. Math.-Physikal. Classe d. k. b. Akad. d. Wiss. zu München, 1880. Heft. III., p. 368 *et passim*. I shall have opportunity to return below to Buchner's assertions in detail, as I shall have to criticise some of his facts and deductions, but at present I wish to point out that one of Buchner's fundamental propositions, viz., that the bacillus anthracis and the bacillus of hay are morphologically (with the exception of the motility of the latter) identical, is altogether erroneous. The two kinds of bacilli are not identical, and never become identical however long they may be cultivated in artificial cultivations, and on this point I must with Koch (Cohn's Beiträge II., Bnd. III., and Aetiol. d. Milzbr., p. 21), most decidedly oppose Buchner. It is true that Buchner admits some very essential differences between the two, but these differences refer to chemical and functional relations. I shall point out below in detail these differences.

Morphology.

Buchner cultivated, at a temperature 35°–37° C. the bacillus anthracis, originally derived from the spleen of a white mouse dead of anthrax, in 0·5 per cent. solution of Liebig's meat extract with or without the addition of peptone or sugar. As a first result of his observations on white mice, Buchner found (p. 383) "that the infectious "activity of the fungus becomes the more diminished, the more "generations it had passed in the artificial cultivations." But on looking carefully into his facts, we notice that the above result does not come out in so simple and regular a manner as is represented in the above sentence. For in one series of cultivations of bacillus anthracis carried on in a nourishing fluid of 10 parts of Liebig's meat extract, eight parts of peptone, and 1,000 parts of water, Buchner found (p. 383 *et passim*) that the inoculations with the 1st, 2nd, 3rd,

Supposed change of potency, by cultivation.

and 4th remove or generation produced always anthrax, whereas those with the 5th, 6th, 7th, and 8th did not yield any positive results, "if "the same quantity of infective material was used," but "if larger "quantities are used, positive results were obtained." In like manner in other series of cultivations, he finds great differences as regards the activity of the bacillus of the various "generations." Thus he found (p. 384) that minute quantities of the 1st cultivation proved effective, whereas the 2nd, 3rd, and 4th in small quantities proved ineffectual. But the 5th cultivation proved effective in large quantities, the 6th was ineffective. In a series of cultivations in meat extract, peptone and sugar, the 2nd cultivation proved active; the 3rd and 4th inactive; the 5th, active; the 7th, 18th, and even the 36th generation proved active. From all these and similar observations Buchner deduces that the bacillus anthracis undergoes a gradual change, by which sooner or later it is rendered altogether harmless and inactive. This change is, however, not one of morphological character. I shall, further below, when describing my own observations on these subjects, have to return to Buchner's observations, and I shall then show that all his facts *are easily explained by the aid of my own observations, but not by the theory of a gradual diminution of activity of the bacillus anthracis.* There is such a thing as a real diminution of activity of the bacillus anthracis in artificial cultivations; the inactivity on white mice of some cultivations of the bacillus anthracis and not of others is due to a variety of circumstances, one of which, at any rate, is this, *the absence of spores.* If Buchner had tested his cultivations on guinea-pigs or rabbits he would have obtained altogether a different result, always supposing that he worked with pure cultivations of bacillus anthracis.

Koch (Zur Aetiologie d. Milzbr., p. 22 *et passim*) considers it probable that Buchner's uncertain and unequal results are explained by the fact that his (Buchner's) cultivations not being absolutely guarded from contamination with other non-pathogenic bacilli, he may have had, and probably did have in some of his cultivations the bacillus anthracis originally sown, diluted or altogether suppressed by the overgrowth of the non-pathogenic bacillus. With Koch I fully think this objection well justified, especially since Buchner does not admit a difference between non-moving non-pathogenic bacilli and the non-moving bacillus anthracis.

[I am acquainted with Dr. Greenfield's paper on cultivations of the bacillus anthracis communicated to the Royal Society on June 17, 1880; but I am unable to find in it anything to which I can attach importance, with the exception of some observations that repeat earlier experiments of Dr. Burdon Sanderson and of Dr. Buchner. In my opinion some of Dr. Greenfield's observations contain internal evidence that he was occasionally operating with some harmless bacillus and not with anthrax bacillus at all; and I cannot admit his claim to speak with authority on the etiology of splenic fever. It may be noticed in this connexion that Koch, in his last elaborate paper on the subject, has not made a single mention of Dr. Greenfield's assertions.]

Liabilities to error.

Buchner noticed, as his cultivations rose in degree of generation, that the bacilli showed a change in their general mode of growth, inasmuch as, unlike their previous behaviour so often described by Pasteur, Koch, and others, they ceased to form the beautiful cloudy and flaky felt-work (Pasteur's "en filaments tout enchêvetrés, cotonneux") rising from the bottom of the culture-vessel into the otherwise perfectly clear nourishing fluid, but they gradually assumed the tendency to adhere to the walls of the vessel. After a duration of cultivation of 90 days (Buchner calls this the 900th generation), this condition became very pronounced, and in

later generations the bacilli formed the same pellicle on the surface as do the harmless hay bacilli. On changing the mode of growth he ultimately succeeded in obtaining bacilli that in this respect did not differ from the typical hay bacilli. With reference to this point I am inclined to think that Koch (Aetiologie d. Milzbr., p. 22) is right in refusing to accept this as proven; he says that Buchner had not sufficiently guarded himself against outside contamination, and therefore it is quite possible that he introduced into his cultivations at one or another step a common bacillus which after several cultivations became so numerous as to replace altogether the original bacillus anthracis.

With reference to Buchner's cultivations, by which (using blood for his nourishing fluid) he gradually changed the common hay bacillus into the bacillus anthracis, Koch (*l.c.*, p. 26) maintains that what Buchner really had before him in those cases in which he had animals die after the inoculation with the hay bacillus cultivated in blood for many generations, was not anthrax bacillus, but the bacillus of malignant œdema (Koch). I think Koch's criticism is very thorough and has every probability for itself. I certainly should be surprised to find that a cultivation in blood treated in Buchner's manner (*l.c.*, p. 405), viz., without any precaution against accidental contamination, and which naturally would undergo putrid changes, did not yield the œdema bacillus; this, when cultivated for several successive generations, as was the case in Buchner's experiments, would at last yield a cultivation in which the œdema bacillus is the only organism present.

Pasteur's attenuated anthrax.

I now come to the most important research of this cycle, viz., that of M. Pasteur. A succinct summary of his results he himself has given us in a remarkable address given during the last International Medical Congress in London in August 1881. This address has been reprinted, with a translation, as a Parliamentary paper, under the title, "Animal Inoculation." It refers to the micrococcus of fowl cholera and to the bacillus anthracis. It is only the latter that interests us here. By numerous previous observations M. Pasteur has found that cultivating the bacillus anthracis in chicken broth at a temperature of 42° and 43° C., the bacillus, although vigorously growing in the shape of the characteristic convolutions of threads, nevertheless does not form spores (p. 10).

"In a month or six weeks the culture dies; that is to say, if one impregnates with it fresh decoction, the latter is completely sterile. Up to that time life exists in the vessel exposed to air and heat. If we examine the virulence of the culture at the end of two days, four days, six days, eight days, &c., it will be found that long before the death of the culture the microbe has lost all virulence, although still cultivable. Before this period it is found that the culture presents a series of attenuated virulences; everything is similar to what happens in respect to the microbe of chicken cholera. Further, each of these conditions of attenuated virulence may be reproduced by culture. Lastly, since splenic fever does not recur (*ne récidive pas*), each of our attenuated anthracoid microbes constitutes for the superior microbe a vaccine, that is to say, a virus capable of producing a milder disease. Here, then, we have a method of preparing the vaccine of splenic fever."

[These are stated as general propositions, and M. Pasteur makes them without mention of any particular kind of animal. He cultivates the anthrax bacillus at 42° C. in fowl-broth, and treats as indifferent the class of animal into which he inoculates the cultivation.]

"I was asked to give a public demonstration at Pouilly-le-Fort, near Melun, of the results already mentioned. This experiment I may relate in a few words. Fifty sheep were placed at my disposition, of which

25 were vaccinated, and the remaining 25 underwent no treatment. A fortnight afterwards the 50 sheep were inoculated with the most virulent anthracoid microbe. The 25 vaccinated sheep resisted the infection; the 25 unvaccinated died of splenic fever within 50 hours. Since that time the capabilities of my laboratory have been inadequate to meet the demands of farmers for supplies of this vaccine.* In the space of 15 days we have vaccinated in the departments surrounding Paris more than 20,000 sheep, and a large number of cattle and horses. This experiment was repeated last month at the Ferme de Lambert, near Chartres. It deserves special mention. The very virulent inoculation practised at Pouilly-le-Fort, in order to prove the immunity produced by vaccination, had been effected by the aid of anthracoid germs deposited in a culture which had been preserved in my laboratory more than four years, that is to say, from the 21st March 1877. There was assuredly no doubt about its virulence, since in 50 hours it killed 25 sheep out of 25. Nevertheless, a commission of doctors, surgeons, and veterinary surgeons of Chartres, prejudiced with the idea that virus, obtained from infectious blood, must have a virulence capable of defying the action of what I call cultures of virus, instituted a comparison of the effects upon vaccinated sheep and upon unvaccinated sheep of inoculation with the blood of an animal which had died of splenic fever. The result was identical with that obtained at Pouilly-le-Fort; absolute resistance of the vaccinated, and death of the unvaccinated."

I have hitherto had no experience with the inoculation of sheep with cultivated bacillus anthracis (but hope soon to be able to gain some); and I cannot therefore say anything about it, nor do I for one moment question the absolute reliability of M. Pasteur's successful vaccination of sheep with bacillus anthracis, and the immunity thus conferred upon them, although no such uniform results were obtained by his assistant when repeating M. Pasteur's experiments in Buda Pesth, but what I will take the liberty of questioning is the general application of these results by M. Pasteur and his followers to anthrax in animals other than sheep, or to the other infectious maladies. For I am able to show, that not only does no such mitigation of activity on rodent animals take place in the bacillus anthracis when artificially cultivated and precluded from forming spores, but that no immunity is conferred on rodent animals, if not succumbing to the effect of such cultivated bacillus anthracis. There are a number of statements by M. Pasteur, such as the oxygen of the air being the cause of the attenuation of the virulence; further, the inability of the cultivated bacillus anthracis to form spores at a temperature of 42° and 43° centigrade; then the assertion that the attenuated virulence once obtained is transmitted to the next cultivation, the accuracy of some of which my experience obliges me to question, of others directly to contradict.

Protection by does not extend to rodents.

Koch's observations.

Koch (Zur Aetiologie des Milzbrandes, in Mittheil. de Kais. Gesundheits-Amtes., Bnd. I., Berlin, 1881) made some interesting contributions to the etiology of anthrax. The most important points in his publication are the criticisms of Buchner's and Pasteur's work on the subject. Although a great deal of what Koch says when speaking in a perfectly objective manner of Buchner's observations is justified, I do

* It is matter of regret that the exact methods of preparation used by M. Pasteur in his laboratory are not made public; so that the present research has had to be conducted in ignorance of his details. The fact of his success in producing what he calls a "vaccine"—a something which when inoculated into sheep produces some modified splenic fever that protects the sheep against the after-production of fatal splenic fever when the virulent material is inoculated into the sheep—may be taken as established.

not think that there exists the same justification for all he says of Pasteur's work. That in the present extended knowledge of anthrax, both in its etiology and pathology, but especially the former, we owe more to Koch's brilliant researches than to the researches of all other observers taken together, including Pollender, Brauel, and Davaine, the discoverers of the bacillus anthracis, will, I think, be readily conceded by all who have had the opportunity of repeating some of Koch's experiments and observations, and have read his several communications on this subject, and it is not want of respect to the other workers in this field to concede this much. It will likewise be conceded, I think, by all who read Pasteur's various contributions on the subject of the etiology of anthrax, that Pasteur would have profited by a more careful study of Koch's observations and writings, particularly that the error of Pasteur's earth-worm theory* might have been avoided if he had felt the significance of Koch's previous observations on the incapability of the bacillus anthracis to form spores within the body of an animal owing to the want of sufficient amount of oxygen, and especially of Koch's valuable observations on the inability of the bacillus anthracis to form spores in the depth of the soil. And, again, objection may perhaps be taken with reason to Pasteur's dogmatic way of dealing with pathological facts, such as his arbitrary definitions and descriptions of what constitutes anthrax and what constitutes malignant œdema.

But while allowing all this, and perhaps even more, I think all must extremely regret the tone in which Koch's criticism is made; all must think that his criticism would have been much more valuable had it kept within strict bounds of an objective statement. Koch shows by means of most valuable observations, some of earlier date, published in his previous writings (Cohn's Beiträge zur Biologie d. Pflanzen, 2 Heft), some of recent date, that no spore formation is possible in bacillus anthracis at a temperature below 15° C. or 59° Fahrenheit. At a depth of 1 meter the temperature of the soil in middle Europe is so low that the formation of spores in bacillus anthracis is practically impossible in an animal buried unopened at that depth. Koch also proves (*l.c.*, p. 20) by very instructive and direct experiments with earth-worms and spores of bacillus anthracis mixed with earth, that Pasteur's earth-worm theory cannot be correct.

Habitat of anthrax bacillus.

Various considerations of the distribution of anthrax in Germany and of the manner of the outbreaks of its epidemics lead Koch to the assumption (p. 29 *et passim*) that the natural habitat of the bacillus anthracis is really in the soil, and that its casual introduction into the body of an animal and the production of anthrax in it, is only "a casual "excursion of a micro-organism not generally limited to such a "parasitism."

As mentioned just now, there is a great deal of evidence for such an assumption, especially the way in which in Germany the disease makes its appearance in animals grazing in fields and meadows which occasionally become flooded. In these instances it is assumed that the bacillus anthracis growing in vegetable infusions (that it does readily do so

* According to this theory spores having been formed in the bacilli within the organs of a buried animal that has died of anthrax, such spores are taken up by earth-worms, carried up to the surface, and then deposited with their castings. From the surface of the soil they find easy access into the mouth or nostrils of animals grazing on that soil.

I shall show in a future report that the bacillus threads as such do not survive even the initial stages of decomposition of the buried body. And it cannot be supposed that earth-worms can feed on buried bodies in the few days that may elapse before decomposition has set in.

in some of them is shown by Koch) of a distant locality or in the depth, is carried by means of water to the surface and is left here when the water is receding or drying up, to find ultimately entrance into the body of an animal grazing on that field. Hay infusions and other vegetable matter, it is true, owing to their acid reaction, do not, according to Koch, form a suitable nourishing fluid for the bacillus anthracis, but Koch draws attention to its being a known fact that the dangerous anthrax localities have a chalky or loamy soil, and it is therefore possible that even where the vegetable infusions in the soil would be acid (hay, some kinds of straw, barley, grass, &c.), the carbonate of lime of the chalky soil would suffice to neutralize the infusions.

Koch (*l.c.*, p. 25) failed to find any diminution in virulence of the bacillus anthracis cultivated artificially up to the 50th successive cultivation, an experience which I am able, as I shall presently show, to confirm.

Method of cultivation.

Nourishing material.

Before I give a detailed description of my own observations on the cultivation of bacillus anthracis, I have to state the method of cultivation which was employed in this inquiry. As nourishing fluid I have employed broth prepared from fresh pork. About a pound and a half to two pounds of pork are boiled in water for an hour or so down to about two pints of fluid. The fat scum is removed and the fluid, provided the pork employed has been lean, filters tolerably clear through filter paper. To obtain it, however, perfectly limpid, the broth is cleared à la cuisine with egg-albumen and then filtered. The filtrate, which will be spoken of as "the pork broth," is of a neutral or faintly acid reaction; in this latter case a sufficient amount of carbonate of sodium is added in order to make it neutral, it is then received in a long-necked flasks which are then plugged with cotton-wool.

In all cases, and I wish to state this once for all, where a cotton-wool plug is spoken of, whether in connexion with a flask or a test tube, it will be understood that a cotton-wool plug of about two inches length is meant, in some instances two plugs one above the other each about an inch long being used. The cotton-wool, the flasks, beakers, filters, filter paper, test tubes, and all vessels used are invariably disinfected by exposing them for several hours, generally repeated several times, to a temperature varying between 140° to 150° C. To use cotton-wool disinfected by prolonged (for several days or weeks) steeping in absolute alcohol, or concentrated carbolic acid solution, is not absolutely reliable. Overheating the cotton-wool in an air chamber to the above temperature till singed has proved invariably and absolutely safe for all cultivations; I have had to my regret failures in my cultivations which could be referred to cotton-wool soaked in concentrated carbolic acid solution even for months. The same is to be said of the flasks and test tubes used. No amount of cleaning, even with strong acid, is to be relied on; nothing but overheating gives reliance. I at first always used to heat the vessel well all round over the open flame of a Fletcher's burner almost till the glass becomes glowing, and soon after when the glass is still hot, but not as to do more than just singe the cotton-wool, I place in its neck the cotton-wool plug, this having previously been overheated in the air chamber. But lately I have overheated the vessels in the air chamber to about 140°–150° C. for several hours, several times repeated, having previously cleaned them with distilled water and dried them as far as possible; and I have found this perfectly sufficient to disinfect them thoroughly. It cannot be too strongly insisted on with Koch that the flasks and test tubes and especially the cotton-wool used as plugs for the vessels should be thoroughly sterilized by overheating, for it is as much and as often that cultivations become thereby contaminated as by the non-sterility of the nourishing fluids or the accidental entrance of organisms from the air.

The filtered nourishing fluid (pork broth), having been received in a clean flask plugged as above stated with long and clean cotton-wool, is boiled for about ten to fifteen minutes. I never fill the flask to more

than half its volume with the broth, in order to avoid the fluid rising too high during boiling, and thus wetting the cotton-wool plug. This, although not necessarily fatal, owing to the sterility of the cotton-wool, nevertheless I always avoid in this and other cases, for the sake of cleanliness and to avoid all possible contamination. Immediately before turning off the flame of the burner and while the fluid is still boiling, I place over the mouth of the flask a cotton-wool cap and keep this pressed over the mouth and upper part of the neck of the flask by an inverted beaker pushed firmly over it. The flask is then placed into an incubator and kept here at a temperature of about 32°–35° centigrade. After two to three days the flask, plugged but without the cotton-wool cap, is again placed over the gas-flame and the broth subjected to boiling for five to ten minutes. While still boiling the cotton-wool cap and beaker are placed over the mouth and neck and the flame is turned off. Such a flask with broth may now be considered absolutely sterile; it may be kept in the incubator for weeks and months, it will always remain absolutely limpid and free of any organisms. Such broth will in the following be always spoken of as "sterile pork broth."

This broth I use either as such, *i.e.* as pure broth, or in combination with gelatine, as "gelatine pork," in order to have, as recommended by Koch (*l.c.*), a nourishing material not of fluid but of solid consistency. I consider, with many others, this method of Koch's, viz., of using gelatine as an admixture to a nourishing fluid, and thus converting it into a solid state, a very great advance indeed in the methods of cultivating bacteria, especially in securing pure cultivations not contaminated accidentally, for then the sowing of a particular species of bacterium is possible in a particular spot or spots, the growth and progress can be easily watched and controlled, and accidental contaminations can be readily recognised, but I shall show below that it is quite possible also without the gelatine admixture after the method I use to be almost absolutely guarded from accidental contamination, *i.e.* to have pure cultivations. Koch has very minutely described the advantages of the gelatine method and his modus procedendi, and he has given numerous photographic illustrations of various species of bacterium in pure cultivations effected by his gelatine method.

Koch recommends, in order to solidify the nourishing material (in his case it was a solution of Liebig's meat extract), to mix with it purified and well sterilized and neutralized gelatine solution in such a proportion that the gelatine would form 2–3 per cent. Such a nourishing mixture is solid at ordinary temperatures and represents an excellent soil for sowing on or in it the desired species of bacterium in dots or lines; kept in flat glass dishes or slides the examination with the microscope can be easily carried out from time to time, and it can easily be ascertained how and whether the sown species is making progress, and accidental contaminations can thus be easily detected and removed, all growths, owing to the solid state of the nourishing material, being naturally limited to the spot or line on which the bacterium has been sown. It is necessary to keep the dish or glass in a chamber (under a bell jar) saturated with moisture. This is, in short, the essence of Koch's method. He maintains that such a gelatine material remains solid at a temperature of 20°–25° C. sufficiently high for the growth of all species of bacteria.

All this sounds very excellent, but when one comes to work with it practically one finds that everything is not as perfect and excellent as one imagines at first.

As is well known from the researches of Brefeld, Grawitz, Wernich and others, nourishing material in a solid state, such as gelatine, boiled

potato, bread, paste, &c., has been used for the sake of obtaining pure cultivations and for the sake of easily watching and keeping under control the progress and growth of particular organisms, *e.g.* penicillium, aspergillus, micrococcus prodigiosus, &c.; but most of these observations were carried on at ordinary temperatures. Koch, however, recommends it, after many observations, in the above form for pure cultivations even in the incubator at 20–25° C. for all species of bacteria (micrococcus, bacterium termo, and various species of bacilli, &c.).

The first difficulty one has to overcome is to obtain a sterile and neutral clear and limpid gelatine solution. I have tried every obtainable kind of gelatine, in which I was much assisted by Dr. George Maddox, to whom I am under great obligations, such as ordinary French gelatine, best Swiss gelatine, much recommended to photographers by Dr. Eder of Vienna, best French gelatine, called gold-label gelatine, isinglass, a peculiar lichen-gelatine used by Chinese cooks to get a very firm jelly, and various other kinds of gelatines; and after a great many experiments, both time-consuming and patience-trying, to enumerate which would be a very unnecessary infliction on the reader, I have found best answering our purpose a gelatine solution prepared in the following manner: one part of "gold-label gelatine" (the tablets in which it is sold being cut up into small strips) is soaked overnight in six parts of cold water, it is then dissolved on the water bath; this solution has a slightly acid reaction; to it is added carbonate of sodium just sufficient to give it a neutral reaction. While quite hot it is filtered through filter paper once or twice. (It must be borne in mind that the filter paper, the vessels receiving the solid gelatine or the filtrate, and all other vessels subsequently used for its reception, are perfectly disinfected by overheating them.) The process of filtering is carried out by using hot filters and filter paper, keeping up the warmth by placing at two opposite sides, as close to the filter as practicable, Bunsen burners. The filtrate is tolerably clear, but can be obtained perfectly clear by adding to it after neutralisation egg-albumen, and then boiling it for several minutes. In this latter case it may be filtered through calico or flannel previously disinfected. To the filtered gelatine are then added three parts (not three times its volume) of the above pork broth, so that we have now altogether one part of solid gelatine, six parts of water, and three parts of pork broth, which would be equal to one part of solid gelatine in nine parts of fluid, or 11$\frac{1}{9}$ per centum. This mixture is received in several sterilised flasks, closed well with long and thoroughly sterilised cotton-wool plugs, and is subjected to boiling for 5–10 minutes. While still boiling, and just before removing from the flame, the mouth of the flask is covered with a cotton-wool cap, and a beaker is inverted over it. The flasks are then placed in the incubator and kept there at 32–35° C. for 24 hours, after which they are again subjected to boiling for about five minutes. This I have found to be sufficient to keep them sterile for ever after. This mixture, which I will speak of as "sterile gelatine pork," remains, even in the smallest quantity, solid up to a temperature of 25° C., a temperature generally sufficiently high for the growth of bacteria.

Koch (Zur Unters. d. Pathog. Organ., p. 24) recommends a mixture of gelatine and nourishing fluid in such proportions that the gelatine amounts to about 2$\frac{1}{2}$ to 3 per cent., and he states this to have served in a solid state for the cultivation of bacteria, not only at the ordinary temperature of the room, but at temperatures varying between 20° and 25° C.

Now, no kind of gelatine which I have been able to lay hold of has kept solid at a temperature of 20–25° C. in such percentage, nor as

5 per cent. mixture, not even as 7·5 per cent. Ten per cent. mixture is the lowest that I have been able to keep solid at such a temperature. It is true a good many bacterial organisms grow tolerably well in a temperature about 15–18° C., at which the 2½–3 per cent. gelatine mixture is solid, but their growth is very slow. In some instances, *e.g.* bacillus anthracis, the growth progresses tolerably well, but in others it is extremely slow. To make spores of hay bacillus sprout at such a temperature is exceedingly difficult, and so it is also with the spores of some other kind of bacilli. I have seen bacilli which absolutely refuse to grow at such a temperature. Of micrococci some grow well, others do not.

It is clear, then, that if, as is the case in laboratory experiments, one requires growth of a particular organism to take place within a reasonable time, not to mention those cases in which organisms do not grow at all at so low a temperature, the above temperature, viz. 15–18° C., is not sufficiently high, and it is necessary to use gelatine mixtures stronger than 2½–3 per cent. The above 11 per cent. mixture of gelatine and pork keeps well and solid at 25° C., and at this temperature all bacteria that I have tried grow well and abundantly.

Thus far I have been describing the manner in which I prepared the nourishing material, viz., sterile pork broth and sterile gelatine pork, which is to serve as stock for the cultivations. I have used also other nourishing material, such as beef broth, rabbit broth, &c., for the cultivation of various organisms; but the subject of the present report is the observations made with bacillus anthracis, and for this I have used hitherto with satisfactory results the pork broth and gelatine pork only, and I shall not enter on the present occasion into a consideration of the other nourishing materials.

I now come to the description of the method of using the above stock of nourishing material for the special cultivations of the bacillus anthracis.

(A.) A number of disinfected test tubes and small flasks are used, the latter of the capacity of an ounce or so, plugged with disinfected cotton-wool, the plug lifted, and each charged as rapidly as possible for a fraction of their volume with the nourishing material from the stock flask, and then plugged with cotton-wool. In the case of the gelatine pork, this is of course first liquefied over the flame. The stock flask, if not emptied by this process of charging, is subjected to boiling from 5–10 minutes. When charged and plugged each test tube and small flask is subjected to boiling for a few minutes; the boiling is effected *over a small flame* in order to prevent the over-boiling; this is not so much to be feared in the case of the flasks as in that of the test tubes. Thorough boiling for once is generally sufficient to destroy every organism that may have accidentally entered during the process of charging. Kept for an indefinite time in the incubator at 32–35° C. the fluid in them remains bright and clear.

(B.) Glass cells of exactly the same nature as those that were of so great use to me in my research on the pneumo-enteritis of the pig (see these Reports for 1877, p. 210), in the majority of instances without any addition, in some with the addition of a thin glass tube cemented to the glass slide and leading into the cell; the outer opening of this glass tube is plugged with cotton-wool. This tube was chiefly added with the view of facilitating the formation of spores, but as a rule I found, cæteris paribus, if the other conditions for the spore formation are present, the amount of air present in the glass cell sufficiently large to enable the spore formation.

As in my former work so also now, I use olive oil to fix the cover glass over the glass ring forming the sides of the cells. The cover glass before being used is well heated over the flame. A small quantity of the nourishing fluid (pure pork broth or liquefied gelatine pork) is withdrawn from the stock flask by a freshly drawn-out small capillary pipette; this is effected in this manner: the cotton-wool plug of the stock flask is drawn up for about half its length, and the one end of the pipette being drawn out into a long capillary tube is gradually pierced through the remaining half length of the plug and pushed down till it reaches the fluid; the pipette is filled and withdrawn, and the plug is again pushed down into its previous position. By this means absolutely no access is allowed to particles from the air into the stock flask, and at the same time the capillary tube, while being pushed through the cotton-wool plug, is cleaned from accidentally adhering particles. It must be borne in mind that for the above purpose the cotton-wool must have been *well sterilised* by heat, because if not so, the nourishing material in the stock flask is sure to become contaminated by impurities adhering to the cotton-wool fibres, some of these being pushed down as well as carried down into the fluid by the capillary tube. From this pipette a drop is quickly deposited in the centre of the cover glass, and this is inverted and fixed on the ring of the glass cell, a drop of distilled water having been previously placed at the bottom of the cell at a peripheral place. The cell is now "charged" and ready to receive the organism that is to be cultivated in the drop of nourishing material attached to the centre of the lower surface of the cover glass. The process of charging the test tubes and flasks, as well as the glass cells, being carried out in the air, is of course subjected to the complication of a contamination with air organisms. In the case of the test tubes and flasks this is remedied by subsequent boiling of the charged and plugged vessels; but in the case of the glass cells a sterilisation after charging is for obvious reasons impossible, and it is therefore necessary to take one's chance, so to speak, of having a number of failures owing to accidental contamination. And it is this very point, viz., the chance of contamination with air organisms, which makes the Koch method, as recommended by him, impracticable in the case of many cultivations, as I shall have to point out below in detail.

Influence of external circumstances.

It depends very much on the place and season where and when the charging is carried out, as regards the accidental contamination with air organisms. I have made some comparative studies on these points, and I think it worth while to enter here more fully into them.

At first, when working at the laboratory of St. Bartholomew's Hospital Medical School, I charged my test tubes from my stock flask under carbolic acid spray, the carbolic acid being of the strength of about 5–6 per cent. From my note-book I gather that in one series I charged 16 test tubes carefully under the carbolic acid spray, and placed them into the incubator at about 35° C. Of these test tubes one went bad in the course of 24 hours, at which time it became turbid owing to the presence of actively moving bacilli. In another series of 14 test tubes two went bad. In a third series of 22 test tubes every one went bad, although the method of charging under the carbolic acid spray was the same as in the other cases; but the conditions of the atmosphere were not the same. While I had tolerably good results in July and August, I had very bad results in October; and my failures, both in preserving sterile my stock fluids and my test tubes charged with them, became during this month so numerous and persistent, that I had to give up work altogether for this period. To have cultivations exposed to the air and not afterwards sterilised, as is almost the general rule in Koch's method of gelatine cultures, and to keep them pure was altogether out of the question. The cause of these universal

nd unconditional failures was not far to seek. During October we had a ood deal of dry weather with strong winds, and the laboratory in which I orked faces Smithfield hay market, whence a good deal of dust was blown nto the laboratory. The dust contained an enormous number of spores, specially of bacilli, as was proved, not only by the direct observation, but also y the fact that every kind of nourishing fluid, Cohn's nourishing fluid, ay infusion, beef broth, mutton broth, pork broth, &c. previously sterile, hen exposed to the air on such windy days for a second became very difficult f sterilisation, boiling for 10 minutes and sometimes 15 minutes, or even ore, did not produce sterilisation. After 48 hours' incubation the fluid was nvariably swarming with bacilli.

During July, August, and September, when days were tolerably still, specially on rainy days, and there were no high winds, test tubes containing sterile nourishing fluid could be kept open, *i.e.*, the cotton-wool plug could be altogether removed, under carbolic acid spray for several seconds, and without being subjected to boiling after this remained sterile at a temperature of 35° C., only a relatively small percentage, varying from 5 to 7, being lost by air organisms. This is not at all an unsatisfactory result, considering that the laboratory faced the hay market, and considering how easily a contamination could occur under these conditions. But at a time with high winds the contamination was so serious that even prolonged boiling after exposure did not sterilise. This is not to be wondered at if we remember that fluids containing hay bacillus spores and some other bacillus spores require for absolute sterilisation boiling extending up to, and even over half an hour (see Cohn's Beiträge, II. Bnd., II. Heft). The results obtained subsequently, when resuming my work, not in the previous locality, but in the laboratory of the Brown Institution near Vauxhall, situated in a less contaminated atmosphere, were very much more satisfactory. Comparative experiments which I here made showed that exposing to the air for half a minute sterile nourishing fluids contained in test tubes, during windy weather, yielded about 50 per cent. failures, while exposing them to air under the carbolic acid spray yielded no failures in one series, it yielded 5 per cent. failures in another series.

As I mentioned above, I charge my test tubes rapidly either with pure pork broth or with liquefied gelatine pork without spray, and then boil them well for a few minutes, and doing this in the laboratory of the Brown Institution I find it sufficient to thoroughly sterilise the fluids.

In connexion with this subject I would draw the attention of the reader to the very important investigation made by Mr. Watson Cheyne (Transact. of the Pathol. Society of London, 1879, p. 577) on the value of the carbolic acid spray in the inoculation of artificial cultures.

Sowing or inoculation of nourishing material.

The plan of Koch of spreading out a large drop or small quantity of liquefied gelatine nourishing fluid on a glass slide, or on a flat glass dish, and having inoculated this on its surface with the desired organism to place it in a chamber closed by a bell-jar or the like, which is kept moist by putting into it (the chamber) moist filter paper, has not been found practicable, owing to the fact that the gelatine nourishing fluid having solidified again, dries up too soon, before the sown organisms have had time to make a start, the moisture all settling on the inner surface of the bell-jar. This condition I have invariably found to obtain, even when the chamber was closed airtight, the bell-jar with ground margin being fixed by lard or oil on to a ground-glass plate. Not only in ordinary temperature, but still more so in the incubator was this drying up of the gelatine nourishing fluid found to happen, and I have therefore modified Koch's plan by using the arrangement mentioned before, viz. the closed glass cells, and the test-tubes plugged with cotton-wool.

The next important step in the cultivation of bacteria in the nourishing material hitherto described, as contained in the test tubes or glass cells, is the inoculation of these materials with the organisms it is desired

to grow, *i.e.*, the process of sowing. It is of course obvious that if it is desired to cultivate a single species of organism, it is necessary to sow a single species, and to prevent contamination with air organisms, the nourishing fluid itself being sterile. With reference to the first, it is necessary to be certain that the material containing the seed and to be transferred into the nourishing material contains no other but the desired species. This is, however, not always a simple matter. It is simple enough in the following cases: if I transfer to my nourishing material a droplet of blood taken from the heart or the spleen of an animal just dead or dying of anthrax, I am certain to have no other organism in the blood except the bacillus anthracis; or if I have an artificial cultivation of bacillus anthracis which from certain definite naked-eye appearances (see below) and still more from microscopic examination of anilin-stained specimens, I can pronounce with certainty to be a pure cultivation of bacillus anthracis, I shall be certain that I shall again, *cæteris paribus*, obtain a pure cultivation, if sowing out from this cultivation. Again, if I take an infusion of hay, in which fermentation produced by the hay bacillus has been completed,—that is to say, in which the bacillus has passed its whole cycle and has yielded an abundant crop of spores forming a fine brown precipitate at the bottom of the infusion,—and if I boil this infusion for several minutes, I shall be sure to destroy everything living except the spores of the hay bacillus, and if I sow out from this so boiled infusion, I shall have the satisfaction to find that the new growth contains only hay bacillus.

The above modified use of Koch's method, viz., charging the covering glass of the glass cell with a drop of liquefied gelatine nourishing fluid, and when this has become solidified again to inoculate it in one or two straight lines with matter containing the bacteria to be sown, *i.e.*, to dip a needle previously heated, or the end of a freshly drawn-out capillary tube into the fluid containing the seeds, and then to draw the needle or the capillary tube quickly across the surface of the drop of gelatine nourishing material once or twice, this method, I say, is invaluable for the study of the gradual changes those bacteria undergo when subjected to incubation, the manner in which they multiply: further to ascertain whether the desired organism has been sown, and whether only one kind of organism or several are growing in the nourishing material; for the glass-cell specimen can be easily examined even with high powers of the microscope from time to time, without in the least disturbing the growth. Koch, in his paper above quoted, has minutely described all these advantages, and therefore I need not further enter into this part of the subject, as I have no doubt it must be obvious to everyone who has the slightest acquaintance with artificial cultivations of bacteria.

If you have sown in this manner a particular organism well known to you, it is of course easily ascertained on microscopic examination immediately after, whether the same is present in any part of the line you have drawn over the gelatine drop in the above glass-cell specimen with your needle or capillary tube. Thus, inoculating the gelatine drop with the bacillus anthracis or with its spores, or the spores of hay bacillus, with sarcina, with torulæ, with micrococcus prodigiosus, &c., you can at once find these seeds in the streak you have drawn on the gelatine drop; according to the number of seeds present in the material to be sown, there will be more or less numerous seed in that streak. If in addition to this, you have sown only one species of those named, any accidental contamination will soon be detected under the microscope in the gelatine drop, say, after a day or two, or longer.

But supposing you are sowing a material of which you do not know whether it contains any organism, or, if so, what kind of organism, the case is altogether different, and the value of this method is not obvious, on the contrary, may lead to serious errors. In this way: the inoculation of the solidified gelatine nourishing material, whether in my glass-cell specimens, or after Koch's plan, on glass slides or flat dishes, must take place in the air, and there is no means to prevent contamination with air organisms. Under ordinary circumstances, and working quickly, the chances of such contamination are not very great, but are, nevertheless, objectionable. Now supposing that you inoculate your gelatine in several specimens with the material to be tested for organisms, you may find after a day or two or more of incubation that in one or more of the specimens in the streak you have drawn there is no growth whatever of any organism, but outside it at other points an organism or several organisms begin to grow, you will justly say that all these organisms are accidental contaminations, air organisms. But if you found in the streak one species or more growing, you cannot conclude from this that you have transferred this or these species from your original material, because your moist needle-point or capillary glass tube may have caught these seeds while passing through the air; and this has actually happened to me, not once, but repeatedly. I have several instances in which I have sown or meant to have sown in one streak over the gelatine drop of my cell specimen a particular species of bacillus, and to my great annoyance I found after several days' incubation in that very streak growing three different species of organisms, viz., one kind of micrococcus and two different species of bacilli. In another instance I wished to test a fluid for the presence of an organism or organisms, consequently I sowed it out on the gelatine in several of my glass cells, and I obtained in the streak drawn over the gelatine drop two species of organisms, a micrococcus and a bacillus; but as I ascertained with a more precise method, the fluid contained no organism whatever. These facts, it must be conceded, prove that the method of Koch, although of great value in certain cases, is less to be recommended in others, and therefore does not deserve that unqualified praise which its author accords to it (*l.c.*) saying as much as that this is the only method after which cultivations of micro-organisms are to be carried on. I shall presently show that there is a more reliable method, (provided the question is one of transferring one definite organism from one fluid into a vessel containing the nourishing material) a method in which the chances of contamination are less, and the method also, for other reasons, more practicable.

The method of inoculation of the nourishing material which I at first used was under the protection of the carbolic acid spray: a freshly drawn-out capillary pipette is dipped into the material to be sown, the cotton-wool plug of the test tube or flask containing the nourishing material is lifted under carbolic acid spray on one side JUST sufficient to admit the end of the capillary pipette; this being done the plug is again closed over the mouth, the capillary tube is pushed down into the nourishing fluid and then quickly withdrawn and the plug completely replaced. In this manner I have been very successful in inoculating, without contamination with air organisms, nourishing fluids with the special organism desired to be sown.

But this method is in so far unpleasant as the spray prevents one from seeing easily the capillary tube while being pushed down into the test tube. Although I used this method a good deal, I have nevertheless recently employed a much simpler method, which yields as good if not better results. In the carbolic acid spray the chances of

contamination with air organisms are small, as I have above stated, and when a contamination with them occurs it is probably through the spray catching them and carrying them into the test tubes, but it must be obvious that this is really only a remote chance, considering that in my cases I only momentarily lift one side of the plug sufficient to admit the end of a capillary tube.

The best and most practicable method which I am now in the habit of using, and which is almost absolutely safe against accidental contamination, is this: the cotton-wool plug of the test tube or flask containing the nourishing material is pulled out for about half its length; a capillary pipette having been charged with the fluid to be sown is then gradually and carefully pierced through the remaining part of the cotton-wool (thereby clearing itself of adhering particles), introducing it between it and the sides of the vessel, it is then pushed down into the nourishing material and a trace of the seed fluid emptied into the former. The capillary pipette is quickly withdrawn and the cotton-wool plug pushed down into its old position. If the nourishing material is gelatine pork, it is of course easily possible at will to deposit the seed from the capillary tube either on to the free surface or into the depth. If the seed fluid is to be obtained from an artificial cultivation contained in a test tube or a flask, it is withdrawn with a freshly made capillary pipette in exactly the same manner as the seed material is introduced into the new cultivation just described. It must be borne in mind that for the success of this method it is imperative, in a greater degree than in the other previously mentioned methods, that the cotton-wool plug is thoroughly sterilised. For it is obvious that if this is not the case, by the piercing of the cotton-wool plug with the capillary pipette wool fibres are always carried down into the nourishing material, and if these are not thoroughly sterilised a contamination of the latter must inevitably follow.

I had charged 12 test tubes with pork broth, and had them well plugged with cotton-wool, well boiled on two successive days, and placed into the incubator at 32–35° C.; they were kept here for two weeks and remained perfectly limpid and sterile. I then inoculated six of them in the above manner with bacillus anthracis of an artificial cultivation, viz., introducing the bacilli by piercing the capillary tube containing them through the cotton-wool plug. After 24 hours all showed signs of accidental contamination. I remembered that I had kept the test tubes for several hours, and at two successive days, at 140–150° C.; but the cotton-wool had been tightly compressed in a beaker and exposed only for about an hour to a temperature of about 120° C. From the remaining six test tubes I removed the plugs of this cotton-wool, and closed them with fresh plugs of thoroughly sterilised cotton-wool. They were well boiled and kept in the incubator for several days; as they remained quite limpid they were inoculated after the same manner and with the bacillus anthracis of the same cultivation as in the case of the first six test tubes; the result was completely satisfactory; no accidental contamination occurred. From this it is clear that the test tubes and the nourishing material were sterile in both instances, and also the bacillus to be sown was the same, and in a pure state in both cases, but in the first the cotton-wool was at fault, hence the accidental contamination introduced into the nourishing material.

As a rule, in cases where the naked-eye appearances do not and cannot give indications of the actual state of the cultivations, *i.e.* whether pure or not, as is the case in most cultivations of bacteria except, perhaps, of bacillus anthracis, I have employed both methods.

i.e., I cultivated in the test tube or flask, and at the same time controlled it under the microscope, by cultivating in the above glass-cell a specimen in a drop of solid gelatine nourishing material.

Cultivations: their appearance.

In the cultivations of bacillus anthracis in the above-named neutral pork broth in test tubes or small or large flasks with which I worked, after three or four or more days' incubation, even at a temperature so low as 20° to 25° C., a beautiful whitish crop of the bacilli is visible at the bottom of the vessel in the shape of a fluffy nebulous more or less filamentous mass as incubation proceeds, gradually extending into the further layers of the fluid, this latter being tolerably bright and limpid. These appearances have been well described by Pasteur and have been also noticed by Buchner (*l.c.*, p. 376). The cultivations which I carried on in the pork broth, from one transfer to the other, all showed these characteristic appearances, except in those few instances in which, as mentioned above, an accidental contamination occurred. These appearances are so striking and peculiar that it can with certainty, from the naked-eye inspection alone, be recognised whether a given cultivation is one of pure anthrax.* If the growth after the first few days does not present the peculiar nebulous and filamentous masses at the bottom of the fluid, if the supernatant fluid remains clouded and turbid, and especially if a scum appears on the surface, either only where the surface of the fluid adheres to the glass or over the whole surface, it can be concluded with probability that the cultivation is impure, there being generally present a micrococcus or a scum-forming bacterium or a bacillus, and this can be easily verified by microscopic examination. During the first two or three days of incubation, however, the fluid is not limpid, but more or less uniformly turbid, the growth not being limited to the bottom layers; but soon this changes, and the characteristic nebulous masses are visible at the bottom, while the rest of the fluid is perfectly clear. The first turbidity is due to the uniform distribution in the fluid of the bacilli, isolated and in chains.

If the vessel in which the cultivation is carried on is kept quiet (I generally keep the test tubes in a beaker with a layer of cotton-wool at its bottom), the peculiar anthrax bacillus growth retains its original naked-eye appearances for a considerable time; shaking the test tube up after several days incubation destroys the coherence of the bacillus mass, and this latter breaks up into small flaky particles, which, however, readily sink to the bottom, so that the supernatant fluid again becomes limpid. As long as sufficient nourishing material is present in the fluid the bacillus mass will of course continue to grow in amount, and when this does not any longer take place the fluid is "exhausted." Now, watching the behaviour of the bacillus mass *afterwards, i.e.*, after the mass has ceased increasing, these important facts become obvious: that the bacillus mass becomes gradually smaller; this diminution is in some instances so rapid and conspicuous that at a first inspection it seems that the cultivation is not the same, but that it might have been changed for another; but there can be no doubt about it if the inspection is made a few days later. This diminution goes on till only a few flaky transparent masses are left in the fluid. Below I shall show what the reason of the diminution is and what the microscopical appearances are. During this process of diminution and disappearance of the bacillus mass the

Exhaustion of nourishing material.

* These appearances are much more striking in neutral cultivations than in those of acid or alkaline reaction. In the latter instances there is never the same copious growth as in the first.

fluid *remains always perfectly limpid.* But I may at once state that this disappearance of the bacillus mass has nothing whatever to do with spore formation, as might be at first supposed; for we know from the researches of Cohn that in a bacillus mass composed of long and convoluted threads, such as the bacillus anthracis forms in these artificial cultivations, the formation of bright oval spores soon sets in. The newly-formed spores become liberated, the bacillus threads become transparent and disintegrate, while the spores sink to the bottom to form a minute precipitate. *There is nothing of the sort in our cultivations.* As a general rule in the flasks and test tubes with fluid neutral pork broth *no spore formation takes place.* Whether the cultivation is carried on at an ordinary temperature, or at a temperature of 20–25° or 32–35° C. there is no spore formation. I have test tubes with neutral pork broth, in which exceptionally spores have been formed in the threads. These test tubes were of the following nature: in one test tube an enormous mass of bacillus threads had made its appearance while the cultivation was kept in the incubator at 22° C. for about three weeks, the masses of threads were very loose and consequently occupied a large volume, so large that the growth extended almost to the surface of the fluid; here numerous spores were found in the superficial threads. Another test tube of exactly the same material inoculated with exactly the same generation of bacillus anthracis, and kept under precisely the same conditions, did not develop any trace of spores; here the mass of bacillus threads formed a more dense growth, and kept its place at the bottom of the test tube far away from the surface of the fluid. In another test tube I found that the mass of bacillus threads at first growing at the bottom of the fluid after some time sent out some bundles of threads which grew along the glass wall to the surface of the fluid. Here also numerous spores were found in the threads. Buchner, (*l.c.* p. 370) says: "The physiological cause of the spore formation "lies in the commencing deficiency of nourishing material." This is proved to be incorrect by our cultivation. The exhaustion of the nourishing fluid is long apparent and no spore formation occurs, and *vice versâ*, spore formation may be observed long before there is any sign of exhaustion of the nourishing matter, so much so that spores appear early in the culture and again become converted into bacilli, but no spores may be formed in this new generation. Pasteur says that he prevents the formation of spores in the bacillus anthracis cultivated in chicken broth, by keeping the cultivation exposed to a temperature of 42–43° C., which is still suitable for the growth of the bacilli, but not for the spore formation; in many instances this is unnecessary, because even at ordinary temperatures no spores are formed. Cohn and Koch maintain that for the formation of spores in the bacillus of anthrax as in other bacilli, a certain degree of warmth, a certain degree of moisture, and a sufficient supply of air are indispensable for the formation of spores. There can be no doubt that this is so; bacillus anthracis does not form spores in the body of an animal, as I can fully confirm Koch against Pasteur, who makes this assumption, and as I have repeatedly convinced myself by direct and systematic observations, to be mentioned in my next Report; but I cannot admit, if it is said that given those three conditions, viz., a certain degree of warmth and moisture, and a sufficient supply of air, supposing other things unchanged, the bacillus anthracis must of necessity form spores. This is by no means the case, for I have seen numerous cultivations in which these conditions were present, but no spore formation ever occurred, although the bacillus went on increasing in numbers in a most satisfactory way. In the cultivations of bacillus anthracis in neutral pork broth in test tubes or flasks, if they

Conditions for spore-formation.

Influences of warmth and air on spore-formation.

are kept quiet, no formation of spores ever occurs. In these instances the absence of a sufficient amount of air is no doubt the cause, as I shall show below, the growth taking place at the bottom of a fluid which had been well boiled for the sake of sterilisation. Dr. Löffler (aus dem Kaiserl. Gesundheitsamte, 1881, p. 134) also suspects that in Pasteur's cultivations it is perhaps not the temperature of 42° or 43° C. which prevents the spore formation, but the immersion of the bacilli in the fluid, for the bacilli form spores at this temperature when cultivated in flat dishes (see below).

Apart from spore-formation, inoculation with bacillus anthracis of gelatine pork in test tubes or flasks (and kept solid) yielded slightly different results, according as the inoculation was established on the surface of the gelatine or in the depth. In the first case the growth proceeds with rapidity, the bacillus forming fluffy masses of convoluted filaments; where these appear the gelatine becomes liquid; and as the growth gradually extends downwards, deeper and deeper layers of the gelatine material become liquefied, the bacillus growth of course occupying the deepest layer of the liquefied material; the liquefied layers above remaining perfectly limpid. In this way the growth gradually comes to lie deeper and deeper, and when the deepest layer of the gelatine has become liquefied, the bacillus mass is at the bottom of the test tube. When this stage is reached the growth does not differ in any respect from one in a test tube of pure pork broth. The same changes, described above, of diminution and gradual dwindling away of the bacillus mass is also here noticed.

Differing, however, from the bacillus growth in pure pork broth, the bacillus growth on the surface of the gelatine pork is capable of spore formation, *as long as the growth is still close to the surface;* but as the superficial layer of the gelatine becomes liquefied by the bacillus growth, this latter gradually takes a deeper position, and since the spores previously formed again germinate into bacilli, a time arrives when no more spores are formed in the bacilli. When a sufficient amount of the gelatine pork has become liquefied so that the bacillus mass being placed at the lowest part of this liquefied portion is away from the surface, no more spore formation is observed; the bacillus threads, however, continue to increase in length and numbers till all the nourishing material is exhausted. But I have some instances where no spore formation took place even at the commencement; that is the case when the inoculation of the gelatine pork in test tubes takes place (though it be at the surface) at a point between the gelatine and the glass. Here the growth increasing burrows itself at once into the depth and liquefies the gelatine on one side in the shape of a pit or channel passing downwards, and as the bacillus mass occupies the deepest position in this pit of liquefied gelatine it becomes removed from the surface, while yet only composed of bacillus threads. And the growth proceeding into the depth and from here into the sides it may happen that the whole gelatine pork becomes liquefied without there having occurred a trace of spore formation in any part of the gelatine material. But I have seen a cultivation in which spore formation nevertheless appeared subsequently, although the bacillus mass has become deeply placed in the fluid gelatine. In this case the same process occurred as is mentioned above to have happened in a test tube of pure pork broth, viz., bundles of threads grew along the glass wall of the test tube towards the surface of the liquid, and having reached this spores, made their appearance.

Spore formation can be, however, easily procured and kept up in gelatine pork in this manner: A flask containing gelatine pork, for

about ¼ or ½ of its volume, is inoculated with the bacillus anthracis in the middle of the surface of the solid gelatine material. The growth naturally spreads from here to all parts of the surface, since growth in this direction is much easier than into the depth owing to the resistance offered by the solid material. The layer of gelatine on which the growth takes places becomes liquefied, and thus the growth passes downwards. Owing, however, to the large surface presented by the gelatine material, the bacillus threads show very copious spore formation, and this spore formation is kept up by the bacillus threads for a long time, since even when the superficial layer of the gelatine has become liquefied the bacillus mass is still near a very large surface of air. This superficial fluid layer can be easily drawn off with a glass pipette drawn out into a thin tube at one end, which is introduced into the flask through the cotton-wool plug, in the same manner as for the purpose of withdrawing a single drop, or of inoculating it in the first instance with some seeds, a method that has been minutely described above. This liquefied mass thus drawn off teems with bacillus threads and spores, multitudes of them being quite isolated. It can be easily discharged into a sterilised test tube plugged with cotton-wool, without contamination with air organisms, and kept here ad infinitum. The fluid mass being nearly or quite exhausted of the nourishing parts, at any rate for the bacillus anthracis and its spores, is naturally unable to supply the spores with the pabulum necessary for germination, and hence these spores remain as such in the fluid. These relations are perfectly in harmony with all that Cohn has taught (Beiträge zur Biol. d. Pfl. II., Band. II.), about the behaviour of the spores of other bacilli, notably the spores of the hay bacillus. Such spores I have kept in the above test tube as a sort of stock, both for the production of fatal anthrax in animals as well as for the establishment of new artificial cultivations.

A new layer of liquefied gelatine teeming with spores is gradually formed in the above flask, owing of course to a continuation of the growth of the bacillus threads and spores left behind, and this layer can be drawn off in the same manner as the former; thus liquefied masses teeming with spores can be obtained and drawn off in succession, until a thin layer of the gelatine pork is left in the flask, in which, owing to the enormous surface, abundant spore formation takes place in the bacillus threads, and for the reasons above stated, many of these spores are retained as such. If we start at the outset with only a thin layer of gelatine pork or pure pork broth at the bottom of a flask, and if we inoculate this with bacillus anthracis, we also obtain here, after a certain progress of the growth of the bacillus threads, a copious crop of spores. This has also been observed by Dr. Löffler, as mentioned above. Many of these spores remain naturally as such in the fluid ad infinitum. We have, then, several methods by which we can with certainty obtain a crop of spores and preserve them ad infinitum. All these observations prove in a most definite manner that for the formation of spores in the bacillus anthracis a rich supply of air is required, and unless the bacillus threads are well exposed to the air, no spore formation takes place in them. Thus the statement of Cohn and Koch are fully borne out by my observations.

If on the other hand the inoculation of the gelatine pork in test tubes or in flasks takes place in the depth, that is to say, if the seed is deposited at the outset at the bottom of the solid gelatine mass, the growth proceeds slowly owing to the resistance of the solid material, but in the same manner as is the case in the pure pork broth. Like a beautiful bed of more or less distinctly dendritically branched weeds the masses of bacillus threads springing up at the bottom of the vessel rise into the superimposed layers. The appearance produced hereby is very fine after

the growth has made some progress; we perceive the growth to rise perpendicularly from a common bed at the bottom of the vessel like a forest of dendritically branched plants. The gelatine of the deepest layer becomes of course here first liquid. This growth does not yield spores at any time owing to being far away from the surface, and it always remains in the state of masses and convolutions of bacillus threads.

The following confirms in a marked manner what has just been said about the spore formation. In a flask filled to a third or fourth of its volume with solid gelatine pork, bacillus anthracis is introduced on to the middle of the surface, as in the case above described. Masses of bacilli soon spread over the surface; the superficial layer of the gelatine becomes liquefied by the growth, and this liquid layer teems with spores. Now, I decant this liquid layer, and having plugged the flask again, subject it to boiling. What will happen? By the process of decanting a quantity of the growth is removed, but a great deal (spores and threads) is still left behind on the surface ready for fresh growth. Next, heating the gelatine mass, and thereby making it liquid, of course all growth (spores and threads) sinks to the bottom of the flask. But boiling the mass for about a minute or so does not kill all living matter. The threads of bacillus are indeed necessarily killed by the boiling; but not the spores. This is proved by the fact that on allowing the gelatine to cool again, it becomes solid, and now all particulate matter is kept enclosed at the bottom of the flask; and a new and beautiful growth of typical bacillus anthracis growing from the spores soon makes its appearance at the bottom of the flask, while the surface of course remains free. One of the finest growths of bacillus anthracis threads in the shape of a forest-like mass of perpendicularly ascending branched minute plants at the bottom was obtained in this very manner; but under these conditions no new spore was formed—the growth of the threads did not reach the surface.

In cell specimens of the kind mentioned above the bacillus anthracis grows very well both in the neutral pork broth as well as in the gelatine pork. In the latter, when kept solid, *i.e.*, at a temperature of about 20–25° C., the progress of the bacillus can be readily watched. The change of the bacilli into the very characteristic homogeneous-looking long threads forming bundles twisted round one another in a spiral manner so as to resemble a cable; the extension of the threads in all directions; the appearance of spores and their full development, come out here with the same beauty as in the previous cultivations. One drawback to the cultivation in cell specimens is the possibility of contamination with air organisms, as has been mentioned before. In many instances the growth of bacillus anthracis proceeds all right for two or three days, even to the formation of spores, but then an unpleasant crowd of moving bacilli, or what is equally common, zoogloea masses of innumerable micrococci cover everything in the field, including the bacilli anthracis. But I have had a good many specimens in which the growth of bacillus anthracis remained free of contamination. In such cases it is noticed that after some days the gelatine becomes also here liquefied. While in some specimens active spore formation is observed, in others, kept and established under apparently the same conditions, there never is a trace of real spores, or at the utmost there is a sort of abortive or imperfect spore formation. In the latter cases the whole growth of bacilli in the preparation gradually disappears, and dwindles down to an insignificant number of hyaline threads, just as was the case with the cultivations in the test tubes and flasks. But whether the growth leads to the formation of spores or not, there is always, already in the early stages when the

bundles of bacillus threads are yet few and not very long, this fact to be noticed, viz., that in many threads there are a good many shorter or longer spaces in which nothing but a hyaline sheath or tube is noticeable, the highly refractive contents or the protoplasm within the tube being wanting; as the growth proceeds the number of such threads with empty spaces in their sheath increases, and whole threads of immense length may be found in this condition, *i.e.*, in the state of hyaline tubes or sheaths from whose interior the protoplasm has altogether disappeared. This is always noticed in the growth of the anthrax bacillus threads in cell specimens; samples taken out at any stage from the cultivation in test tubes or flasks show the same condition, viz., there are always present longer or shorter threads, which either entirely or partially have become barren of the protoplasm inside the sheath. In cell specimens, it is possible to ascertain that the growing ends of the threads which may be found in the peripheral part of the drop as straight filaments with a rounded end, are always full of protoplasm, and that the deficiency in protoplasm commences at some distance from the end. By-and-by the greater number of threads may thus lose altogether their protoplasm, and hereby become quite transparent and almost lost to sight, but a careful inspection can still detect their presence. Some appear ultimately to break up altogether. This change, viz., the disappearance of the protoplasm in the threads from place to place, is associated, generally but not always and in all places, with the appearance of irregularly sized granules in the tubes, these disappear gradually, becoming evidently dissolved and absorbed, and the then sheath appears at such a place or places quite empty, *i.e.*, without containing any solid protoplasm. These granules are not spores, as I shall show below. I consider it merely a form of degeneration or death of the protoplasm. Another change in the cell specimens is the appearance of spherical corpuscles, either isolated or in close rows or chains; in this latter case we have a thread of regular varicose appearance, not unlike a chain of torulæ. The size of these spherical corpuscles is in their best development that of a human red blood corpuscle, and in aspect they are identical with the gonidia of an oïdium or the cells of torula, *i.e.*, within a cell membrane they contain clear contents and in this a minute nucleus. They become elongated and by fission divide into, or by gemmation produce, two new spherical corpuscles. The growing ends of the threads seen at the marginal part of the specimen sometimes are connected with such a chain of spherical torula-like corpuscles, and in this respect the appearances bear a striking resemblance to the formation of gonidia by mycelium threads. This change also has nothing whatever to do with the formation of spores. It can be ascertained to exist always also in the cultivations in pure pork broth and gelatine pork in the test tubes and flasks. In some cultivations in the neutral pork broth I have met with it very extensively already after a few days incubation. With great distinctness and profusion I have seen it in cultivations in gelatine pork carried on at the temperature of the room.

Microscopy of changes in bacilli.

The observations which I have made on the life-history of the bacillus anthracis differ in some respects from those of previous writers. Starting with the bacillus anthracis of the blood, introduced into the cultivations of neutral pork broth or of the mixture of this broth with gelatine, it is invariably the rule that, as noticed by other observers (Koch, Pasteur, Buchner, and others), the bacilli grow out sooner or later into long homogeneous-looking threads which form bundles, the individual threads coiling round one another in the manner of the wires

of a cable. But there are always some short bacilli, or chains of them and short threads; especially in the former it is noticed in the fresh state and after staining, that their ends are not so blunt as is usually represented, but that they are slightly rounded; and the same rounded appearance is also noticed on the ends of the threads, which are undoubted anthrax bacillus threads. In all specimens of gelatine pork above described the rounded conditions of the ends of the threads is easily perceived.

In the first few days the cultivations of neutral pork broth invariably show, as mentioned above, a uniform distribution of shorter or longer bacilli, isolated and in chains. These gradually lengthen and then of course by their weight settle down at the bottom of the fluid whence they grow upwards into the characteristic long convolutions. I presume the uniform distribution of the bacilli and the general turbidity of the fluid caused hereby in the early days is due to the bacilli following Brownian molecular movement, as well as to their being able to float in the fluid, but when they grow out into long threads their weight and the cessation of molecular movement draws them down to the bottom of the fluid, which for this reason then becomes clear. That the isolated and short chains of bacilli causing the general turbidity of the cultivation in the first few days are really anthrax bacilli as much as the typical long threads afterwards formed, is shown by the fact that if with these latter a cultivation is started it presents the turbid appearance in the first few days, and secondly, at any stage the smallest quantity of the cultivation kills with typical anthrax guinea-pigs and rabbits.*

With Abbe's condensor and Zeiss' oil immersion objectives it is possible to discover in these threads, already in the fresh and living state from place to place, a differentiation of a thin sheath forming the tube, as it were, and a protoplasmic contents, and this protoplasmic contents appears subdivided into a single row of short, almost cubical blocks or cells. In many places this subdivision of the protoplasm into cells or even the differentiation into sheath and protoplasm is not distinct in the fresh state, but comes out with greater or lesser distinctness after staining or after certain reagents. Thus, for instance, careful staining them fresh with anilin dyes (gentian violet, methyl violet, methyl blue, Spillers' purple, &c.) brings out in many places this differentiation into sheath and protoplasm, and the subdivision of the protoplasm into square or rather cubical individuals or cells. Adding a nearly concentrated solution of acetate of potash to the fresh preparation brings out these appearances also very well. Still more, and in fact with marvellous distinctness, does it come out in dried and stained specimens (after Weigert and Koch). Watching the bacilli of the spleen or any other organ while drying under the microscope, the gradual differentiation into sheath and cubical cells can be followed very readily. I have made an endless number of stained specimens of bacillus threads of my cultivations in pork broth and gelatine pork, and have invariably found the same appearances, provided the specimens be not overstained, or if so, well washed with alcohol, viz., the whole protoplasm of each thread is subdivided into a single row of cubical cells, stains well with the anilin dye, and distinct from the general sheath of the thread. Koch

* These peculiarities of the early bacillus growth may or may not be connected with the ability of that growth, which is not possessed by later stages of the same growth, to kill mice that are inoculated with it. However that may be, these early peculiarities have no relation to spore formation. Spores have, indeed, nothing in common with these rounded ends and cubical cells, which stain in a way that spores do not stain, and have a quite different shape and refractive power.

has pointed out that the bacillus anthracis shows in dried and stained specimens a very characteristic subdivision into shorter or longer rod-like structures, and by this alone bacillus anthracis can be distinguished from other bacilli. He gives in his work (Cohn's Beiträge II., Bnd. III.) a photograph to illustrate this point. In this illustration the subdivision of the protoplasm is not by any means numerous, far less than in my case, for I find the individual members not rod-shaped but cubical. It is true here and there it is seen that instead of a cubical we have an elongated or rod-shaped cell, but in some of these we can clearly discover a slight constriction in the middle, a sign of commencing division into two. The independence of the common sheath of the thread and these cells Koch has not noticed.

But also in the bacilli of the blood and spleen of mice, guinea-pigs, and rabbits, dead of anthrax, I have noticed precisely the same distinction into common sheath and the subdivision of the protoplasm into cubical cells, or when the cells are elongated a middle constriction was noticeable. Accordingly the length of a bacillus, viz. whether, a longer or shorter rod, or a longer or shorter thread, depends entirely on the number of cubical protoplasmic cells contained within the common sheath. The cells may be seen aggregated into two's or into four's, that is, forming longer or shorter rod-aggregations.

Bacilli obtained fresh of the spleen of an animal dead of anthrax show in some instances an absence of the protoplasmic contents within the sheath; this may be only limited to a small spot or may involve the greater part of the length of the bacillus. In sections made of hardened or fresh organs of an anthrax animal, after staining with logwood, or still better with anilin dyes, the same appearance may be met with, viz., limited, deficiency of protoplasm in some bacilli. Koch (*l.c.*, p. 40, and Plate V., figs. 29 and 30) mentions this appearance of stained bacilli from the spleen of an anthrax rat.

On a former page I have described a similar local deficiency of the protoplasm in bacilli and bacillus threads in the artificial cultivations at all periods of growth, even at the earlier stages, and in these circumstances the deficiency extends in some threads over long distances and in consequence only the hyaline transparent sheath of the original thread is left, and this ultimately may also become broken up.

Changes other than spore formation.

It appears to me very probable from numerous observations that in every bacillus at some period of its growth one, two, or more consecutive cells may cease to grow and to multiply. These cells die if spore formation does not occur in them, and their death is indicated by a granular disintegration of their protoplasm and a final solution and absorption of it. In this case the sheath of the bacillus thread remains empty at this place. Such bacilli and bacillus threads are thicker than the unaltered ones.

The division and gemmation of the above-mentioned torula-like corpuscles or gonidia leads to the formation of chains, at first entirely composed of torula-like gonidia; by active division of these gonidia the chains rapidly elongate; in a further stage the gonidia are transformed into oval elongated cells, which are thinner than the original gonidia, and ultimately they change into rod-like cells, again thinner than the oval cells. When the latter stage is reached we have already to do with the typical thread of an anthrax bacillus. In some such threads there are seen numerous places in which the preceding stages of oval cells and of spherical gonidia can be easily recognised. We have, then, here before us a new form of growth of the bacillus anthracis very similar to that of an oïdium growing in a fluid.

The diminution of the bacillus mass in the artificial cultivations in test tubes and flasks described on a previous page is due to the degeneration and disappearance of the protoplasmic cells in the threads, so that at first the transparent sheaths are left, and they also break up ultimately. This degeneration takes place chiefly on the plan of a gradual granular disintegration of the cells within the sheath. In the first stage of this process, and especially if the preparation has been stained, it is noticed that instead of the cubical mass of protoplasm representing one cell, we find either one large granule or a delicate dumb-bell joined by a shorter or longer thin pale bridge. These appearances I have seen in many places in undoubted anthrax bacillus threads; of an accidental admixture there can be no manner of talk, since the general sheath passes uninterruptedly over all unaltered and altered cells. In a further stage of disintegration the granules dwindle down and are ultimately altogether lost. Koch figures (Unter u. path. Organismen, Plate VII., fig. 39) thin bacilli showing a similar appearance to that just described; in Koch's case they were not anthrax bacilli, and Koch does not decide whether this appearance means spore formation or not. I am quite confident it has nothing whatever to do with spore formation, although I at first thought this to be the initial stage of it (see Cohn and Koch); but in my case there is at no time to be seen in them a trace of a bright oval spore. The whole protoplasm of a thread may give origin to these granules; they become smaller and smaller and more numerous and irregularly distributed in the sheath and ultimately altogether disappear.

In some instances I can see something like a thin septum stretching between some of the cells and fixed to the membrane of the common sheath, but I cannot be quite certain about a septum being present between each two cells. I think that the sheath of many a bacillus, be it short or long, be it a straight thread or a curved one, is traversed by such septa at relatively few places; in many places it is a continuous membranous tube in which the protoplasmic cells lie in a single row. In threads in which the above-mentioned granular degeneration occurs the presence of septa can be easier ascertained than in perfect bacilli, but one must not confuse them with transverse discoid débris within the tube. In some such tubes it is seen that many compartments contain one cell; others contain two cubical cells or one oblong; and still others there are that contain three cells, one oblong and two cubical ones. In threads in which the above-mentioned nodose swelling up of the cells has taken place there are distinct signs of septa between the individual cells, especially where the degeneration comprises a whole row of cells.

Varieties of bacilli.

Comparing the bacillus anthracis of heart's blood or spleen of a mouse, guinea-pig, or rabbit, dead of the disease, with the bacilli and bacillus threads grown in the cultivations of neutral pork broth, or in a mixture of this and gelatine, it is found that the organisms are almost twice the thickness of those taken from the animal. I do not refer to the bacilli and threads in which either granular degeneration or the torula-like swelling in its cells or spore formation is going on, for these are naturally thicker, but I refer to bacilli in which unaltered protoplasm is contained within the sheath.

Ewart (Quarterly Journ. of Micr. Scien., April 1877) maintains to have observed a transition of the ordinary non-moving bacillus anthracis into flagellate-moving bacillus. I can only say with reference to this, that in all my observations, whether conducted in test tubes or in cell specimens, there was never anything of the sort observable. Ewart took no precaution whatever against contamination with other bacillus,

and therefore his observations lose all value, since it is probable that he had before him an ordinary flagellate bacillus.

Buchner (*l.c.* p. 394) also claims to have seen a transition of a non-moving typical bacillus anthracis into a flagellate bacillus, but in Buchner's case this is supposed to have come about in a gradual manner after more than 1,100 generations. Notwithstanding the imposing number of generations, I nevertheless doubt the reality of this transformation, since Buchner's cultivations are open to the objection that they were contaminated with an air bacillus. Besides, Buchner, in connexion with this very transformation, makes certain statements as regards the influence on this transformation of the acid reaction of the hay infusion in which the bacilli were cultivated and transformed into flagellate innocuous hay bacilli, statements, I say, which I know to be incorrect, as I shall show later on. He says, for instance, (*l.c.*, p. 392), "that the "slight acidity of hay-infusion prevents altogether the growth of the true "bacillus anthracis." This statement is to me unintelligible, since I have seen bacillus anthracis starting off into a very good growth in acid hay infusion, as well as in other acid nourishing fluids. This statement of Buchner's, if it is to be accepted at all, must be accepted to mean something else than what Buchner infers, viz., that the true bacillus anthracis in the acid hay infusion used by Buchner had no chance against the hay bacillus growing in it, and of which Buchner had not quite got rid previous to the inoculation with bacillus anthracis.

Mechanism of spore formation.

I have mentioned above some of the conditions under which spores were formed in my cultivations, and I wish now to state the manner in which this takes place. Examining in the first state the bacillus of such cultivations in which spore formation is just commencing, it will be found that the protoplasm of the bacilli and bacillus threads appears slightly granular. Where no spores appear it is uniform in aspect. In the granular ones are seen here and there bright glistening spherical, or rather cubical and elliptical, or rather rod-shaped spores. The spores are slightly truncated at their ends, and slightly convex where in contact with the sheath. Staining such specimens with Spiller's purple it will be found that the granular as well as the homogeneous protoplasm stains readily and deeply, whereas the spores, both the spherical as well as the oval ones, remain unstained, and therefore contrast well with the rest of the bacilli. This same relation is exhibited by specimens stained with other anilin dyes, but best with gentian violet and Spiller's purple. The different parts of the bacillus threads show a great difference with respect to the number of spores. In some places there is for long distances a single cubical or oblong spore contained in the thread; in others they are more numerous; and still in others they follow one another as numerously as the elementary cells. It is found that wherever a spore appears it is at once either cubical or elongated, and conspicuous by its glistening appearance and remaining unstained. The cubical ones when ripening become elongated, but always remain of the bright appearance; it is further true that each cubical spore belongs to an elementary cell, but where this latter has become elongated and slightly constricted, preceding division, as mentioned on a former page, we may find two such spores contained in it. In some places the cubical spore remains single in the oblong cell. The elongated spores are as a rule placed parallel to the long axis of the bacillus; but in some places I have seen one or the other spore placed in a diagonal direction. The elementary cell containing a spore still possesses a trace of protoplasm around the spore; but this remnant of protoplasm sooner or later breaks altogether away, and the spore is free

of it. I have, however, seen spores which after having left the sheath of the thread, still showed at one end a trace of the protoplasm.

According to the facility with which spores are formed in a cultivation, we find the number of spores formed in a bacillus thread varying. In some threads every cell for some distance may develop a spore, in others numerous cells remain always without spores, and their protoplasm crumbles down into a granular débris. Under all conditions, however, the thread becomes much thicker, the sheath swells up, and gradually is lost as such. In some cell specimens I noticed an abortive formation of spores; these appeared as irregularly distributed spherical small spores, which never grew into the typical fully-formed large elongated spores.

The conclusion we then arrive at from all these observations is this: Under most favourable conditions every elementary cell is capable of forming a spore; these spores are bright and glistening, and do not stain (see Koch). At first they are spherical, afterwards larger and oblong. If the cell is an elementary or cubical one, it forms one spore; if it is elongated and constricted, *i.e.*, before dividing, it may form two spores; not all the protoplasm of the cell is involved in the formation of the spore, a trace of it is left around the spore, but sooner or later crumbles away as a granular débris. If the conditions are not so favourable, only a limited number of cells form spores, in the rest the protoplasm degenerates into granular débris, and under unfavourable conditions, especially in the absence of a sufficient supply of air, no spore is formed in any of the cells. When spores are formed they escape after the sheath breaks down.

Ewart (*l.c.*) maintains to have observed a division of the spores after they had become freed of the bacillus sheath. This statement also requires confirmation. The above-mentioned couples of spherical spores Ewart also noticed, but they are not due to a division of spores as Ewart maintains, but are developed as such in an oblong dividing cell.

Inoculation of rodents with anthrax.

I now enter one of the most important parts of this research, viz., the results of the inoculation of rodent animals with the bacillus anthracis of the artificial cultivations described above.

Method.

At the outset I wish to state the manner in which the inoculations were carried out. The animals used were white and tame brown mice and offsprings of both, further guinea-pigs, and rabbits. As a rule the mice were inoculated into the subcutaneous tissue of the tail, the guinea-pigs and rabbits into the inguinal skin or subcutaneous tissue, or into the skin of the ear-lobe. The infective material, blood of an anthrax animal or bacillus of a cultivation, is collected in a capillary tube freshly drawn out and is then blown out into a small incision made into the true skin or subcutaneous tissue, according as desired, with a sharp blade that has been before perfectly disinfected in the gas blowpipe. By this method of inoculation I always made certain of not getting any contamination by the instruments,—syringe and cannula that may have been used in previous inoculations. In some cases I used also Pravaz syringes, viz., when I inoculated with blood of anthrax and expected fatal anthrax; for in this case, even if the syringe should not have been cleaned of anthrax particles of former inoculations it did not matter. Knowing the great difficulty of thoroughly disinfecting Pravaz syringes, heating not being available, I did not practice as a rule inoculation by means of the syringe. In the case of guinea-pigs and rabbits a syringe can be always dispensed with, since a capillary pipette drawn out to a fine point and charged with the infective material is as easily inserted to any distance into the

More or less of inoculating material.

inguinal subcutaneous tissue as the cannula of a hypodermic syringe. A minute incision having previously been made, the capillary pipette is emptied of its contents as usual, *i.e.*, by blowing into the near end of it. But even into the subcutaneous tissue of the tail of a mouse a capillary pipette drawn out into a fine point can be easily advanced for a distance sufficiently long for safe inoculation. In all my inoculations with blood and with fresh cultures I have used only very minute quantities of the infective material, a portion of a droplet to a drop, and I found that as a rule the quantity of the material introduced was, if other conditions were equal, seldom a matter of any importance. Buchner and Greenfield speaking of the early stages of successive cultivations, maintain to have had to introduce in some cases larger quantities of the same material than in others in order to produce an effect, owing to the activity of the material having become diminished by cultivation in the former and not in the latter. These statements may be, and probably are, best explained after Koch, by the assumption that the original cultivation had become contaminated by another bacillus; the bacillus anthracis remaining in the minority is gradually overgrown after a certain period or after a certain number of cultivations by the contamination bacillus, and hence larger quantities of the fluid are to be used to get hold of one or the other stray bacillus anthracis left therein, and after some more transfers the original number of bacillus anthracis had become so much diminished that perhaps even a larger quantity contains no other than the contamination bacillus. In my cultivations I never noticed such a condition, *i.e.*, I never found reason for supposing the anthrax bacillus to undergo change in its virulence, otherwise than as there might be question of spore formation on the one hand, or of degeneration (that rendered the bacillus completely inert) on the other hand. I have indeed, on occasion, found an exceptionally large quantity of inoculating material to be required; but this circumstance has always appeared to me perfectly well explained through the small number of really active bacilli existing in the particular material. This has taken place, *e.g.*, in cultures of pure bacillus anthracis without spores, that had been kept for some weeks (see below), and where there had been a gradual diminution of the number of active anthrax bacilli.

A point of importance which I wish to mention here refers to the time of death of rodents after inoculation with anthrax. As a rule they die within 48 hours from the time of inoculation: some within 20 hours, others in 30 or 36 hours, and a few others between this and 48 hours. Few animals survive the third day, although I have seen mice and guinea-pigs die after five days, of typical anthrax. A given cultivation used after the same method and in the same quantity for the inoculation of several mice will kill some of them more rapidly than it will kill others; and the same is true if guinea-pigs are the animals under experiment. I have seen animals (mice and guinea-pigs) die within 20 hours after inoculation with infinitesimal doses of artificially cultivated bacillus anthracis. The presence of spores makes no difference to the rapidity of death. A guinea-pig inoculated with spores that had been first of all frozen with ether spray, and then allowed to thaw, died within 24 hours.

Observations on Inoculation.

It is not necessary for me to enter here into a description of the symptoms of anthrax in rodents, since these are well known through the various descriptions already existing, and I may refer the reader especially to those given by Koch in his several writings on anthrax.

But one fact I must mention here, viz., the great irregularity presented by the spleen in the animals (mice, guinea-pigs, and rabbits); in some instances the spleen is very much enlarged, in others it is not enlarged at all, but in all instances it contains bacilli, though the number of these varies considerably, without, however, standing in any relation to the duration of the illness.

1. Inoculation with blood of an animal dead of anthrax:

With anthrax blood.

The blood was derived from the heart of mouse, guinea-pig, or rabbit, either quite fresh, or after one, two, three, to eight days. In all instances death followed after the introduction of infinitesimal doses. Before inoculation I ascertained that the blood contained the bacilli in sufficient numbers to make it pretty certain that some bacilli will be present even in so minute a quantity. When using infinitesimal doses it is necessary to bear this in mind for the following reasons: supposing the point of a needle is well steeped into the blood of a guinea-pig or rabbit dead of anthrax, and then with this needle the skin of a mouse, or guinea-pig, or rabbit is pricked down to the subcutaneous tissue; out of 10 such inoculations the chances are that all 10 will be successful; but supposing the point of the needle be well dipped into the blood of a mouse dead of anthrax for some hours, and the inoculation be performed as above, out of 10 such inoculations the chances are that there will be several failures. The reason lies in the peculiar way the bacilli are distributed in the blood fluid, being now most of them collected in masses, owing to being held together by a granular, imperfectly coagulated fibrine. Dipping the point of a needle into the blood, it may chance that the point of the needle does not take up one of these coagula,—they being sometimes large and far between, and in this case the inoculation will be unsuccessful. A similar connexion, *i.e.*, the aggregation of the bacilli by granular coagula, may be also observed in guinea-pigs and rabbits some time after death, but not to such an extent as in mice. I well remember to have been rather puzzled one day about the inexplicable cause of death of four of my mice that had been inoculated with anthrax, but apparently did not show any bacilli in the blood. The animals had been dead for some hours (less than 20), and specimens of blood of the jugular vein and heart withdrawn with a capillary pipette, and used for microscopic preparations, did not reveal the presence of the bacilli. I then made specimens of the tissue of the spleen, which organ was only slightly enlarged, and found it teeming with the characteristic anthrax bacilli. I examined the blood again, and especially collected from the cavity of the heart blood with the blade of the knife so as to get out not only fluid blood but coagula as well, and then I met a number of large coagula crowded with the bacilli. These peculiarities, in fact, account for several cases in which I thought at first to have to deal with animals refractory against anthrax; but on inoculating them again with guinea-pig's blood containing uniformly distributed bacilli, they all succumbed. The older the blood, and the longer it has remained within the body of the dead animal, the less chance there is of its retaining the bacilli in a living condition, and the greater also the chances of these bacilli having disappeared and other saprogenic bacilli having made their appearance. These points have been well ascertained by Koch, and I can fully confirm them. I shall have to return to this point in a later Report, in which I shall give the results of a systematical inquiry into this death of the bacilli in the organs of an animal dead of anthrax. In some instances I have had opportunity of using grey mice for my inoculations, and also bastards of white and grey mice, but did not notice any refractory power possessed by the former against anthrax

blood. Some observers have noticed a certain amount of resistance offered to the anthrax virus by the grey mouse, but in these instances they were wild mice, whereas in my cases they were born in captivity and tame.

At the seat of the inoculation with blood in mice the place is always more or less marked as slightly discoloured, and a little tumid, but since death as a rule occurs within 36 hours there is not much chance of inflammation. After the inoculation of mice with blood, and the same applies to other anthrax material, as well as to artificially cultivated anthrax, the animals appear in perfect health until a short time, sometimes half an hour or an hour before death; they are very lively and feed well, nothing in their condition reveals the presence in them of the seed of death, when suddenly they become quiet, their movements become impeded, their breathing rapid, and their temperature begins to sink; and after half an hour or even less, sometimes more, up to two hours, they are dead.

So remarkably sudden is this change from apparent health to a sickness rapidly and surely fatal that this form of the disease has in Germany received the name of *fulminirender Milzbrand, Teufelsschlag* (Röll, Lehsbuch d. Path. und Ther. &c., Wien, 1876, I., p. 493).

In guinea-pigs I noticed on inoculation of blood or any other anthrax material and artificial cultivations *into the subcutaneous tissue* of the inguinal region, as a rule before the day is over, *a distinct œdematous swelling;* this increases gradually till the animal dies, which in the case of blood happens generally within 36 or 48 hours. Death is also here rapid, but not so rapid as in mice, since the animal becomes quiet and weak several hours before death takes place. On post-mortem examination the subcutaneous tissue of the inguinal region and abdomen, especially on the side of inoculation, shows much œdematous swelling. Near the seat of the inoculation there are a few hæmorrhagic spots, but the œdema is generally free of blood; cutting into the tissue a quantity of clear serum flows out that contains only very few bacilli if examined soon after death. Later on their number is much increased. In some cases, especially of prolonged illness, this œdema is so extensive that the subcutaneous tissue of the inguinal region, abdomen, and chest is uniformly infiltrated with the serum. This œdema I have not missed with very few exceptions, in the cases of inoculation of bacillus anthracis and their spores, no matter whence derived, *if the inoculation is made into the subcutaneous tissue of the inguinal or abdominal region*, but it was absent if that of the ear-lobe was the seat of inoculation. That in our case we have to do with veritable anthrax there can be no manner of doubt from the symptoms, the nature of the bacilli, and their distribution in the organs. Pasteur mentions a similar appearance of œdema in some of his sheep.

In rabbits the œdema is not so frequent as in guinea-pigs, nor is it so pronounced, but nevertheless I have met with it in several instances of inoculation into the subcutaneous tissue of the inguinal region.*

It must be, however, understood that this symptom of subcutaneous œdema in guinea-pigs after inoculation into the subcutaneous tissue of the inguinal region occurs not only after the inoculation with blood or with tissues, but equally distinct with artificially cultivated bacillus and its spores.

* What the meaning of the statement of Wernich's (Central. f. med. Wiss., N. 1. 1882, p. 217) is, that rabbits "although not absolutely refractory, nevertheless are very little susceptible" to anthrax, I cannot comprehend, since I have never found a rabbit escape death after inoculation with anthrax blood or artificially cultivated active bacillus anthracis.

Inoculation into the corium itself of the inguinal region of guinea-pigs produced only very slight œdematous swelling about the point of inoculation; in rabbits such an inoculation is not associated with œdema.

---

2. Inoculations with artificially cultivated bacillus anthracis.

With anthrax of cultivations.

The experiments which I wish to mention here were made with bacillus anthracis derived from the mouse, guinea-pig, or rabbit killed by inoculated anthrax, after this bacillus had been cultivated in the neutral pork broth or the neutral gelatine pork above described. In the following I shall of course only take into account the cultivations which from the unaided-eye aspect, the microscopic examination and the experimental results of inoculation with them, are to be considered as undoubtedly pure cultivations of bacillus anthracis. The first remove of bacillus anthracis from the anthrax animal will be considered as the first cultivation, the remove from this into a new cultivation the second cultivation; from this, again, a third cultivation; from this, again, a fourth, and so on. As a rule as soon as a cultivation showed a good crop of the bacillus, a next cultivation was established from it by transferring into the sterile nourishing material an infinitesimal part of a drop of the parent cultivation. In some instances, especially when the cultivations were kept at a temperature of 32–35° C. there was a copious growth of bacillus obtained already after two or three days, in other instances, if the incubation was carried on at 20–25 ° C., I generally waited about six or seven days before utilizing the cultivation for the establishment of a new cultivation.* To term the cultivations "generations," as Buchner does, seems to me altogether arbitrary; his "1,500 generations' are no more in reality 1,500 generations than they are "150 generations," as Koch is only too leniently inclined to admit (*l.c.*, p. 24). A "generation" could really only be called a new crop of bacilli produced from spores of bacilli. If a bacillus grows out into a long convoluted thread or threads, *i.e.*, if one or several elementary cells continue to divide till they have formed a chain of enormous length, then we have no more right to call this chain a ful generation than we have to consider the initial cell of the bacillus thread as the parent, the second cell derived from this as the first generation, the third cell as the second generation, and so on, for then we could no doubt get millions of generations in the very first cultivation that we established with the bacillus taken from the blood. But even if in a cultivation spores are formed, this cultivation need not represent one generation only, because the spores first formed may, and as a rule do, germinate into new bacilli; these or their offsprings again form spores, then germinate into bacilli, and so on within the same cultivation, as long as nourishment is present. But in Buchner's case there must have been cultivations in which spores were never formed. In whatever way we look at it, we cannot fix the meaning of the term "generation," and therefore we cannot speak of a cultivation as a "generation."

Earlier:

At the commencement of my experiments I used white mice for testing the activity of fluids and cultivations containing bacillus anthracis, since, as is well known from Koch and others, these animals are very susceptible to anthrax. Inoculation with a given cultivation of blood bacillus in neutral pork broth kills mice, guinea-pigs, and rabbits, when used during the first few days of incubation; but soon a difference sets in, for *after the first few days* inoculation

* For convenience's sake, I shall speak of the days of exposure of a cultivation to a constant temperature in the incubator, as being days of "incubation."

Later: activity lost on mice.

of mice with the same cultivation proved fatal only in a certain percentage of cases, and after several days more a good many mice remained perfectly unaffected by the cultivation. My *cultivations were typical and perfectly pure*, as I ascertained by microscopic examination and further experiments; there were the typical convoluted cable-like bundles of the threads; on staining they were beautifully "cellular" in structure; inoculations of new cultivations which I made came up very finely. And *inoculations with infinitesimal doses in guinea-pigs and rabbits produced typical anthrax.* The above mice were inoculated, some by Pravaz syringe, others by deep incision and placing into this a drop of the cultivation. The inoculation was repeated in some instances, but without effect; the mice remained perfectly free of illness. This result was obtained with the cultivation, in some cases within a week, in others after a longer period. How could this be explained? Were all these mice refractory to anthrax? Were they refractory only to the artificially cultivated bacillus anthracis? Were they attacked by it, but did not die, as was the case in Pasteur's experiments with the "vaccine"? Had the cultivated bacillus lost its virulence or altogether its specific effect after the first remove from the blood, and thus putting the cultivations of Buchner and Greenfield altogether in the shade? These were questions that presented themselves for solution.

Query: "protection."

As I mentioned above, of the purity of the cultivation I had no manner of doubt; for this I had the most cogent reasons. I must state in connexion with this, that I refer not only to the use for inoculation of the cultivations in fluid pork broth, but also to cultivations carried on in gelatine pork in a microscopic cell specimen above described, where from day to day I could follow the increase in number and length of the bacillus threads. Such cultivations were also used for the inoculation of mice, and if containing no spores, proved without effect. Another point I must not omit to mention, the method or rather methods of inoculation used with mice were perfectly reliable, since really active material introduced in the same manner proved efficacious.

That the mice were not refractory to anthrax—[it would have been a most extraordinary thing if I should have happened to get hold of one refractory mouse after another; I have not found a mouse that was really refractory* to anthrax, if the proper material is

* In several instances of mice I have noticed what seems to denote a certain resistance offered to the anthrax virus on the part of white mice, viz., that some of my animals did not become affected by the virus the first or even the second time they were inoculated with it. Thus I noticed some that resisted the action of the cultivated bacillus anthracis of a first cultivation; then they remained also unaffected by the introduction of typical anthrax bacillus threads of a second cultivation, and on a third time being inoculated with blood bacillus remained nevertheless alive. They succumbed, however, on a fourth inoculation with bacillus spores of an artificial cultivation. Another mouse remained unaffected after the introduction of anthrax blood filled with bacilli, but succumbed to the influence of an artificial cultivation of anthrax bacilli filled with spores. The inoculation in these cases was carried out in the way described above, and I have no doubt that the material was properly introduced into the subcutaneous tissue of the tail. Not seeing any reason to accept in the first instances a refractivity of these particular animals to the anthrax virus —for they succumb to it ultimately, thus proving that they were susceptible to the virus,—it remains as the most probable explanation to assume that the virus although locally introduced, was for some unknown reason not carried into the general circulation. That in our instances it was the resistance offered by the tissue of the tail to the life of the bacillus anthracis, which prevented the development of the disease is not a probable reason, since there exists no real resistance to the anthrax bacillus of either mice, rabbits, or guinea-pigs to prevent the fatal result generally produced after such incubations.

A similar negative result after first inoculation I have noticed also in a few of my guinea-pigs, where the fluid had been introduced into the subcutaneous tissue, and also in a sheep. But in both cases a second inoculation with the same virus produced positive results. The virus was introduced during the first inoculation in sufficient quantity very safely into the subcutaneous tissue.

used; every one of them inoculated once or twice with it died]—was proved by the fact that they one and all succumbed, to anthrax afterwards when inoculated with a different but active material. And this latter circumstance proves at once that they had not been "vaccinated," in the sense of Pasteur, or any other sense, by the first inoculation, that in fact the first inoculation produced absolutely no disease. But, secondly, had the bacillus as such lost its virulence by being taken from the blood and cultivated in an artificial medium? Not in the least, because the very same bacillus killed mice in the first few days of the cultivation, and later on it killed guinea-pigs and rabbits within 48 hours by typical anthrax, and blood of these animals killed without fail within 36 hours. What is more than this, *the very same cultivation which failed to kill a mouse or mice at one time, killed them without fail at another, provided the bacillus had in the meantime had the opportunity to form spores.* And this fact, viz., the presence of spores in the cultivation, is of the utmost importance in respect of the fatal efficacy of the artificially cultivated bacillus on the mice.

Activity on mice renewed with spore-formation.

Pasteur, as mentioned above, produced a certain incapability of the bacillus to kill sheep, by growing it at 42–43° C. By these means he maintains to prevent the bacilli from forming spores which prove fatal to sheep when inoculated. I have mentioned above that in my cultivations in neutral pork broth, in which the bacillus mass remains quiet at the bottom of the vessel, no spores are formed, and it is such a cultivation which proves inactive on mice only. In Pasteur's case the sheep inoculated with such bacilli (prevented from forming spores) are not killed by anthrax, but "vaccinated," and protected against the most virulent anthrax material. I have not yet succeeded in discovering the method employed by M. Pasteur, (and the details of which he has not published) for the production of "vaccine" protective against anthrax: and I can only say that in the case of mice there is no such diminution of virulence as Pasteur has obtained in the cultivation with which he inoculates his sheep. The mice not killed or even injured by the pure bacillus threads of our cultivations succumb without fail to an inoculation *with spores or blood bacillus*, or to an inoculation with the early stage of a new cultivation of bacillus derived from the former cultivation. This inefficacy of the bacillus of the cultivation on the mice, after several days' cultivation, must be borne in mind when judging of Buchner's results above quoted. Buchner (*l.c.*, p. 384) finds the greatest irregularity in respect of the supposed deterioration in virulence of the cultivations, for while in one series, the third and fourth cultivation is inactive; the fifth active if used in large quantity; in other series other results are observed. Granted that Buchner had pure cultivations, of which, however, there is no sufficient evidence—see Koch (*l.c.*, p. 25),—these irregular results, I think, might be explained by the assumption that the active cultivations were *fresh* or contained *spores*, the inactive ones were of some age and had no spores, Buchner's cultivations being carried on in a fluid medium, and being used solely on white mice. More difficult is it to explain Greenfield's statements. He speaks of mice, guinea-pigs, and rabbits as all giving identical results under all circumstances, and this as if the identity of result were matter of course and of necessity. I do not propose to comment on his statements.

Sheep "vaccinated" by Pasteur.

As has been already indicated, a given cultivation of bacillus anthracis, although speedily becoming inactive on some mice, proved under all conditions and for a considerable length of time, fatal to guinea-pigs and rabbits, no matter whether spores had developed in it or not. This

different behaviour of mice on the one hand and guinea-pigs and rabbits on the other, towards an artificial cultivation of bacillus anthracis without spores, came indeed after a while to be a useful means to decide whether a given cultivation of bacillus anthracis, *after several days' incubation*, contained spores or not. I have so often repeated the following experiment that I am confident it can serve as a typical one. A sample of a cultivation of bacillus anthracis in neutral pork broth, which appears to the unaided eye a typical growth, and in which cultivation the bacillus mass is left quiet at the bottom of the test tube or flask for a week or two, when examined under the microscope, does not contain any spores. Inoculate with it half-a-dozen mice and half-a-dozen guinea-pigs or rabbits. All or most of the mice will probably remain well, all the guinea-pigs and rabbits die within 48 hours. Allow the bacillus of the above cultivation to form spores, by sowing them on to gelatine pork, and keeping them well exposed to the surface, or establish a new cultivation in neutral pork broth, and now inoculate the above six mice, or as many other mice as you like, with this new cultivation in its early stage or with the above spores, every one of them will be probably dead within 36 or 48 hours.

No immunity conferred on ice.

The conclusions to be drawn from this seems to me obvious. Mice, unlike guinea-pigs and rabbits, are insusceptible to the bacillus anthracis when cultivated artificially in neutral pork, after this cultivation has been kept for some time, provided no spores are formed in the bacilli. ***But no immunity of any kind is by such inoculation conferred on the mice.*** Since mice are very susceptible to the bacillus anthracis of the blood and tissues of an anthrax animal in which notoriously no spores occur, and since they are (equally with guinea-pigs and rabbits) susceptible to the spores of the artificially cultivated bacillus anthracis and to the bacillus of a fresh cultivation, it seems to me it follows from the facts, as a necessary conclusion, that this insusceptibility must depend both on the mice as well as on a change in the bacillus.

I have made several series of observations, to be detailed at a future period, by cultivating bacillus anthracis in acid pork broth, and to my great surprise the first cultivation, and also sometimes the second cultivation, of blood bacillus anthracis in this acid pork broth formed spores, and consequently killed all mice when inoculated into them in infinitesimal doses; but as cultivation was carried on into a third and fourth, the bacillus, although still copiously and typically growing during the first four or five days, nevertheless did not form spores at any time. As a consequence it did not prove effective on many mice; ***but it proved fatal on guinea pigs and rabbits*** when inoculated into them in minimal doses.

Number of successive cultivations.

What has been said in the foregoing paragraphs, respecting the effects of inoculating with a given cultivation of bacillus anthracis in neutral pork broth and in gelatine pork, applies not only to the first or the second cultivation, but also applies, in exactly the same manner and to exactly the same degree, to the third, fourth, fifth, sixth cultivation, and even (as I have proved by my own observation) to the twentieth or thirtieth cultivation of the bacillus in like nourishing material. As each new sample of sterile material is inoculated from a former sample, a typical and copious growth of bacillus threads takes place in it. If the material be pork broth, spores will not be formed in it, as long as the growth takes place undisturbed below the surface of the liquid. And each successive sporeless cultivation will after a few days (and always

within a week or two) lose its power to kill mice, though it will retain for about two months the same power that preceding cultivations possessed of killing guinea-pigs and rabbits when inoculated into them.

If any of these cultivations of bacillus anthracis in neutral pork broth or gelatine pork are kept for several weeks, it will be noticed, as described above, that the mass of bacilli gradually diminishes in a conspicuous manner. On a former page I have pointed out that already while active growth is going on in the cultivation, some threads undergo degeneration, and when the pabulum in the cultivation is exhausted, this degeneration gradually extends over the whole growth. As a rule, as pointed out before, if during active growth the bacillus mass has been kept at the bottom of the fluid, no spores are formed, and therefore degeneration after the exhaustion of the pabulum gradually destroys every active particle of the growth. Thus it happens that the cultivation, taken as a whole, gradually loses its virulence, inasmuch as with the progress of the degeneration extending over greater numbers of bacilli, larger doses must be injected into guinea-pigs and rabbits to produce fatal result. But this must not be taken as identical in meaning with what Buchner calls a diminution in virulence of a cultivation. According to Buchner larger quantities have to be used of a later generation (*cæteris paribus*) to produce the same result as with a former generation, because, he tells us, the bacillus anthracis is gradually changing its nature, becoming gradually converted into an innocuous hay bacillus.

Effect of degeneration in a cultivation.

In our case the diminution in virulence of a cultivation is entirely due to a diminution in the number of active bacilli, and not to any progressive weakening of the potency of each several bacillus. Wherefore the greater the number of bacilli destroyed, the fewer undestroyed or active bacilli will be found in a given quantity, or what comes to the same thing, a larger quantity of material must be used in order to meet with an active bacillus.

While there exist any living bacilli in the cultivation it is possible to start new cultivations, which when used in the early stage of the new cultivation or when allowed to form spores kill without fail all rodents. I have made several experiments in this respect, and I have invariably obtained the same results.

A first cultivation, which promptly killed guinea-pigs during the first fortnight when used in infinitesimal doses, failed to kill a guinea-pig when injected into the subcutaneous tissue after one month; a sample examined under the microscope showed hardly a trace of a well-preserved bacillus and no spores. I inoculated a test tube of pork broth with it and produced a beautiful growth of typical bacillus anthracis; some of these extended up to the surface and formed a copious crop of spores. This killed a guinea-pig three weeks after it was established. In the above case it was evidently only a chance of our missing to have an active bacillus in the samples which we used for the inoculation of the guinea-pig; but more luckily we got one in the sample used for the inoculation of the pork broth in the test-tube.

The above guinea-pig which escaped anthrax was not immune against the introduction of the active virus, since it succumbed to an inoculation afterwards with bacillus and spores of a cultivation in gelatine pork.

All these observations seem to point out that there are two conditions to be borne in mind: (*a*) a peculiarity possessed by mice and not possessed by guinea-pigs and rabbits; and (*b*) a peculiar change that the bacilli of the artificial cultivation undergo as the duration of incubation advances. As regards the first of these conditions it is

Relation of bacillus changes to inoculation results.

known through Chauveau that Algerian sheep are altogether refractory against anthrax, and consequently these Algerian sheep possess a peculiarity not owned by the French sheep.

According to Pasteur the influence of the air (oxygen) on the artificial cultivations of the micrococcus of fowl cholera, and the artificial cultivations of the bacillus anthracis has a deleterious effect, inasmuch as it gradually weakens and ultimately altogether destroys the activity of the respective organisms. As I have no experience of the micrococcus of fowl cholera, I cannot say anything about it; but of the bacillus anthracis I can say something from my own observations, and I will undertake to offer to this theory of Pasteur, viz., of the deleterious influence of the oxygen of the air on the bacillus anthracis, an unconditional opposition. If in a cultivation we meet with a copious production of typical and beautiful anthrax bacilli and threads thereof; and if we find that owing to the absence of sufficient oxygen these bacilli fail to produce spores; and if we further find that after a certain time the bacilli undergo degeneration, and not being able to form spores owing to the absence of sufficient oxygen, they generally all disappear from the cultivation: I think we are justified in concluding that the conditions are exactly the reverse of what is postulated by the theory of Pasteur; in concluding viz., that it is the *want* of sufficient oxygen which destroys the bacilli. *If oxygen had been present in sufficient quantities, the bacilli would have formed spores and the cultivation would have preserved its full virulence for an indefinite period.*

Pasteur, as mentioned above, maintains that his cultivations, kept without spores, gradually lost all activity. "If we examine the virulence "of the culture at the end of two days, four days, six days, eight days, "&c., it will be found that long before the death of the culture the "microbe has lost all virulence, although still cultivable." My observations bear out to a certain extent this statement of Pasteur, inasmuch as the cultivation lost its power to kill mice before it lost its power to kill guinea-pigs and rabbits. But *as regards guinea-pigs and rabbits it does not hold good;* for in their case complete want of power to kill has appeared in my experience to be the same thing as want of power to grow in a cultivation. Pasteur further states that the animals inoculated with the mitigated virus remain immune against further attacks of anthrax. It is evident that Pasteur's process of cultivation must in some way have differed from my own, or that his assertion for "animals" generally is too broad, for as regards the mice of my experiments there is no immunity of any kind conferred on them.

Pasteur in his cultivations, found, that owing to the diminution of virulence, as time went on, he could at will choose for inoculation a fluid of less and less virulent effect, from one that would produce a fatal effect to one that would have only a slight or local effect. But, says he, sheep inoculated with such a cultivation, which, owing to having been kept for a certain length of time, produced no fatal effect, are "vaccinated" and protected from anthrax in a virulent form.

As regards my mice, guinea-pigs, and rabbits, I have not found anything of the sort. Either the inoculation with my cultivations is fatal or it is not; in the latter case it has no effect whatever, and does not at all protect against active virus; in the former case it is always fatal. The inactivity on mice of a cultivation may be due to the absence of spores, or to the age of a cultivation—Pasteur's statement of a diminution in virulence in two days and four days does not quite cover my facts,—or the bacillus mass in a cultivation, not being able to form spores and gradually degenerating and dwindling away and becoming macerated

into a granular débris, loses after a time altogether its power to infect mice, guinea-pigs, or rabbits, or to start new cultivations.*

These latter conditions come out especially strikingly in cultivations of bacillus anthracis carried on in acid pork broth. I have made a sufficient number of observations to state this positively, and I have seen such a cultivation losing its infective power both for animals and for new cultivations after five days, no other organism making its appearance in it, and the original mass of bacillus anthracis having altogether broken up.

The important statement by Pasteur, that "each of these conditions of "attenuated virulence may be reproduced by culture," is not borne out by my observations, since every one of the cultivations containing only anthrax-bacilli but no spores, and incapable of producing any effect on mice, is invariably capable of starting a new cultivation proving fatal to all rodents *when used fresh.*

I have before me a fourth cultivation of bacillus anthracis in neutral pork, which had proved fatal to guinea-pigs and rabbits. It had never any spores and the days for its activity on mice had passed. After the lapse of two months it was again examined and there were found in it bundles of degenerated bacilli, as well as a few good bacilli. Inoculated into a guinea-pig in minute doses it proved without result, but it started a good and copious new cultivation of typical anthrax-bacillus threads, which killed a guinea-pig with typical anthrax in 20 hours. Pasteur maintains that if a cultivation is weakened in activity by keeping it for some days, it is capable of starting a new cultivation, whose activity is also weakened; that is to say, the bacillus having become modified by time, transmits to its offspring this acquired mitigation. In the case of the cultivations of bacillus anthracis in neutral pork or gelatine pork there

---

* As regards the slight effect (constitutional disturbance and rise of temperature) produced in cattle after inoculation with anthrax blood of rodents (Sanderson and Duguid), or with artificially cultivated bacillus anthracis (?) of a rodent (Greenfield), as well as the non fatal effect produced on sheep by Pasteur with his vaccine, we have to deal with peculiar conditions, not solely due to a diminution of virulence of the bacillus, but chiefly to *some peculiarity* (breed appears to be one of such peculiarities) of the animal inoculated. These cases are comparable in a certain sense to those mild cases of other infectious maladies, which not occurring more than once during the lifetime of an individual, would naturally confer immunity on this individual against a second attack. Thus, a person once having had a mild attack of scarlatina, measles, &c., very likely remains free from a second attack. In cases of scarlatina the differences in the severity of the attacks are due to differences of the source of the virus, [*i.e.*, differences of the nature of the virus], as well as to differences of the individuals attacked,—cases of varying severity being derived from the same source, *i.e.* the same virus. The same is also noticed in the cases of anthrax produced by the bacillus anthracis; the bacillus of some cultivations is altogether ineffectual on mice, deadly on guinea-pigs and rabbits, while it appears to produce, according to Pasteur, only a slight effect on sheep. Now, no one could say this difference is due entirely to a change of the bacillus, since it is equally due to the difference of the individual. Again, the non-fatal result with the blood bacillus of a guinea-pig, dead of anthrax, produced in a cow contrasts strongly with the invariably fatal result produced by the same bacillus on mice, guinea-pigs, and rabbits.

It is very curious to find that Greenfield talks (Veterinarian, 1881) of a certain immunity against fatal anthrax conferred on cattle by his artificial cultivations, although these animals showed considerable illness after a further inoculation with blood of man or guinea-pig dead of anthrax. He had already learned that cattle do not die after blood inoculation, even when not inoculated previously with any artificial cultivation. If he had inoculated his cattle with the blood of a guinea-pig or man (woolsorters' disease), *without* previously inoculating them directly with artificial cultivations, the result would have been precisely the same. This appears to me to furnish decisive evidence of Greenfield having had to deal, not with cultivations of bacillus anthracis, but with some other harmless bacillus.

was nothing of the sort. As long as a cultivation, no matter which, contains living bacillus anthracis, it is capable of starting a new cultivation, and this as well as its parent is capable of killing guinea-pigs and rabbits.

All that has been said of the first, second, third, fourth, fifth, and sixth cultivations of bacillus anthracis in neutral pork broth holds good for the 10th, 11th, 12th, 13th, and so on cultivations. In no instance have I seen, with reference to its infective power on mice, guinea-pigs, and rabbits, any difference of behaviour from that mentioned of the previous cultivations.

It is altogether impossible for me to understand how Greenfield (Veterinarian, 1881) could have come to the conclusion, that once arrived at the eighth cultivation, he already knew that no fatal effect could be produced with it. He has tried the effect of his cultivations on mice, guinea-pigs, and rabbits; but with pure cultivations of anthrax bacillus, the result is to some extent the reverse, since guinea-pigs and rabbits are killed by any cultivation, provided there are living anthrax bacilli in it.

The conclusion, it seems to me, forces itself on us that Greenfield's, like Buchner's, cultivations, were impure; and the further away from the earlier cultivations the smaller the number of the anthrax bacilli, until the contaminating innocuous bacillus gets altogether the mastery in the cultivations, and then the anthrax bacilli gradually disappear altogether.

Of the power of resistance spores are capable of, an idea may be gained from the following facts.

I have tried to ascertain whether the spores of bacillus anthracis in my cultivations become killed, like the bacilli themselves, through boiling or freezing. As regards the first process, boiling a minute or two does not destroy the life of the spores. I have thus treated, as mentioned on a former page, spores contained in a flask of gelatine pork, and have obtained afterwards from them a copious crop of bacilli proving fatal to guinea-pigs and rabbits. I have similarly exposed in a capillary pipette fluid full of spores to the influence of ether spray, and having thus kept the fluid well frozen for several minutes, have injected it into the guinea-pig and rabbit with fatal result. I then subjected spores in the same manner to repeated freezing, each time for several minutes, the freezing being also carried out by the ether spray; but these spores nevertheless retained their full virulence. Before 48 hours were over the inoculated animals were dead of anthrax. I then placed a capillary tube filled with spores in a mixture of ice and salt, and kept it here for one hour exposed to a temperature of 12 to 15° C. below freezing point; after thawing the material was injected into the subcutaneous tissue of a guinea-pig. This animal died of typical anthrax during the third day. There was, however, no œdema about the seat of inoculation.

Such a low temperature, viz., 12 to 15° C. below freezing point (or 21–27 degrees Fahrenheit below freezing point) does not occur in the soil of middle Europe or of these kingdoms, even in the depth of the coldest winter, and therefore spores of bacillus anthracis formed in the soil from the bacillus anthracis that happens to be growing there in a suitable nourishing material (vegetable infusion, &c.) are practically indestructible.

As an addition to our knowledge of the mode of propagation of anthrax in animals the following facts may not be valueless. In *several*

instances I found that of a mouse, that had died of anthrax, a great portion had been eaten by its fellow companion not inoculated with anthrax: its neck, heart, lungs, and liver had all been swallowed up, *but nevertheless the mouse that had thus feasted on anthrax remained perfectly well.* Koch (Die Aetiologie d. Milzbrand, p. 13) is very strong on the communicability of anthrax through simple ingestion from the alimentary canal in animals and man. The above facts do not support this theory as regards mice, for no mouse would escape *inoculation* with an infinitesimal dose of blood of anthrax. They are, however, well in harmony with those of Pasteur and Toussaint, who maintain that in the case of sheep the production of anthrax in these animals by ingestion is in reality due to an inoculation with anthrax into the mucous membrane of the mouth, owing to small wounds and abrasions produced there by the material mixed with the food.

The important question as to the preservation of the activity of the bacillus anthracis within the body of the dead animal, although commenced, is not advanced enough to be here reported, and therefore must be reserved for a further report. Also the observations on the changes the bacillus anthracis undergoes when cultivated in acid and alkaline fluids. Some of these observations have been already touched upon, but others of equal importance cannot find room here to be discussed. But this much I will state already now, that I have ascertained that, contrary to what Koch and Buchner have found, bacillus anthracis is capable of growing in acid fluids, and that it most undoubtedly behaves in a different manner, both as regards size, mode, and time of degeneration and formation of spores, in alkaline and acid cultures, from what it does in neutral nourishing fluids.

In conclusion, and as concerns the more general question which has been held in view throughout the present report, it is to be observed that the theory of the transformation of a pathogenic organism into a non-pathogenic septic organism, as expressed by v. Nägeli and regarded by Dr. Buchner as being capable of direct proof, is not supported by my own investigations into the characters of the bacillus anthracis, which has appeared to retain its full power to produce specific disease as long as it has retained any power at all. And in regard of that particular bacillus, it is further to be noted that its behaviour towards sheep in Pasteur's hands is not the same as its behaviour towards rodents in my own experience; so that we must remain unable to accept, as a general proposition, the general view of attenuation that Pasteur would propose.

EXPLANATION OF FIGURES.

PLATE I.

FIG. 1.

From a specimen of blood of a guinea-pig that died of inoculated anthrax; the specimen had been prepared after the Weigert Koch method (drying and then staining it with anilin colouring matter). Magnifying power about 1,000.

a. The bacilli.
b. The blood corpuscles.

FIG. 2.

From a preparation of an artificial cultivation of bacillus anthracis; the preparation has been prepared in the same manner as that of Fig. 1, showing an arrangement of the elementary "cells" in groups of four. Magnifying power 1,000.

FIG. 3.

From the same preparation as Fig. 2. Part of a bacillus thread, showing at the free (upper) end its composition of spherical torula-like cells. Magnifying power, 1,000.

FIG. 4.

From the same preparation as the preceding figure. Parts of three threads *b*, and *c*, in which the torula-like cells are numerous. Especially in *c* the growing (upper) end is entirely composed of them. Magnifying power, 1,000.

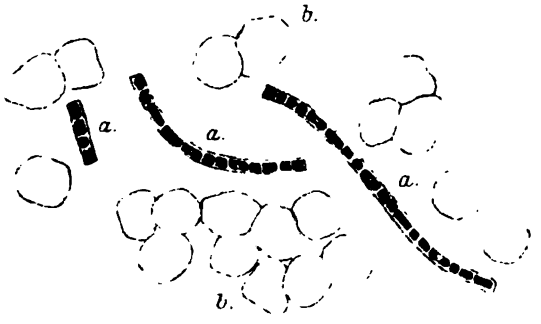


Fig. 1.

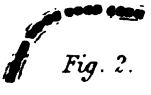


Fig. 2.

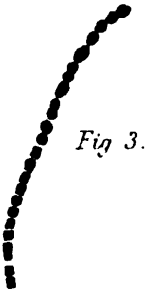


Fig. 3.

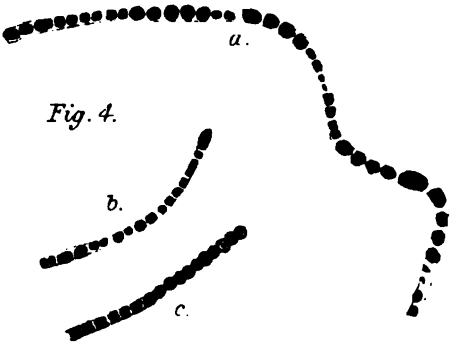


Fig. 4.

DANGERFIELD. LITH 22. BEDFORD S' COVENT GARDEN

Fig. 5.

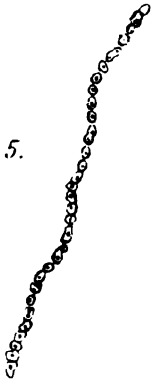


Fig. 6.

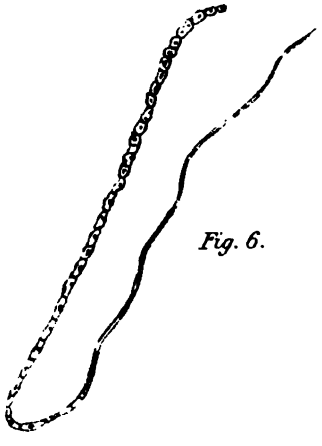


Fig. 7.

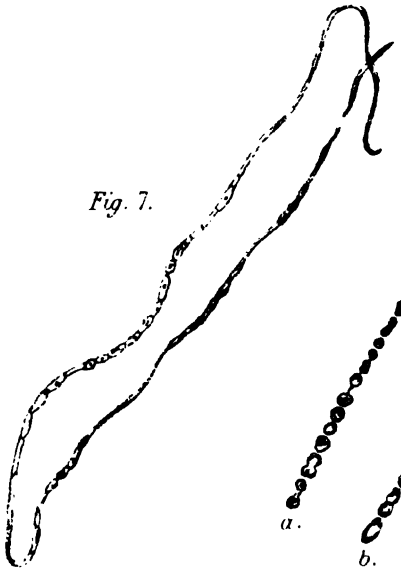
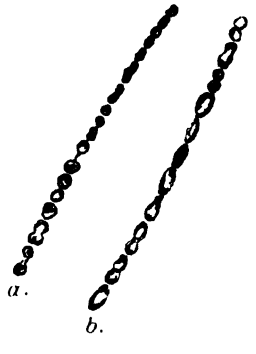


Fig. 8.



DANGERFIELD. LITH 22 BEDFORD ST. COVENT GARDEN

PLATE II.

FIG. 5.

From a fresh preparation of an artificial cultivation of bacillus anthracis, showing a chain of torula-like cells. Magnifying power about 500.

FIG. 6.

From the same specimen as Fig. 5, showing a thread of bacillus anthracis, which at the free (left) end is composed entirely of torula-like cells. Magnifying power, 500.

FIG. 7.

From the same specimen as Figs. 5 and 6.

A typical thread of anthrax bacillus, in some places showing torula-like cells, more or less elongated.

In several places a gradual transition is noticed between the typical smooth bacillus thread and the part composed of torula-like cells.

FIG. 8.

From a specimen of the same cultivation as the preceding figures, but dried and stained. Magnifying power about 1,000.

a. Part of a thread in which the torula-like cells are recognised undergoing division.

b. Some of the torula-like cells are oval, others are in a state of division.

PLATE III.

FIG. 9.

From a preparation of an artificial cultivation of bacillus anthracis. The specimen had been prepared after the Weigert Koch method. Magnifying power about 700.

a. Part of a thread, showing an early stage of granular degeneration of most of the component "cells."

b. Part of a thread further advanced in the process of granular degeneration, very few cells are intact, most are degenerating, at (x) in several cells the protoplasm has entirely disappeared, sheath and septa being left behind.

FIG. 10.

From a specimen of artificial cultivation of bacillus anthracis; Weigert Koch method. Magnifying power about 700.

Showing part of a bacillus thread; the component cubical cells are distinct, in some of them, at *a*, the bright spores have made their appearance.

FIGS. 11 and 12.

From a similar specimen as in the preceding figure. Portions of threads in which only few elementary cells are left, and in some of these bright spores have made their appearance. Magnifying power at about 700.

FIG. 13.

From a similar specimen as the preceding figures. Part of a thread showing the component cells; in almost all of them spore formation is taking place. Magnifying power about 700.

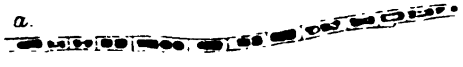
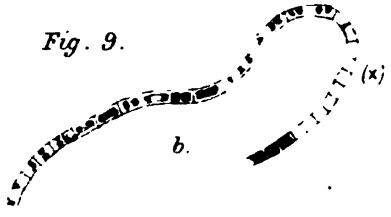


Fig. 9.



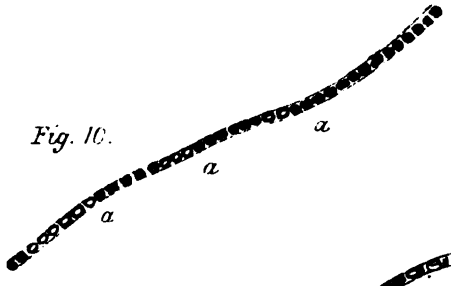


Fig. 10.

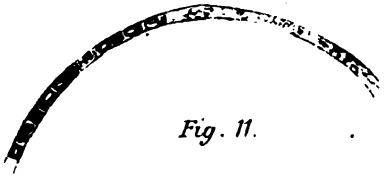


Fig. 11.

Fig. 12.

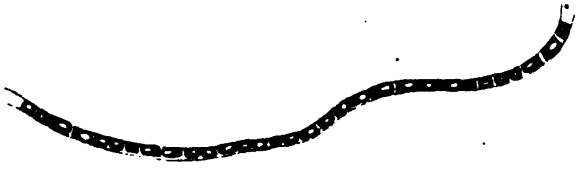


Fig. 13.

Dangerfield. Lith 22. Bedford

No. 3.

SUPPLEMENTARY REPORT on the WOOLSORTERS' DISEASE in the BRADFORD DISTRICT; by W. S. GREENFIELD, M.D., late Professor Superintendent of the Brown Institution.

THE following report embodies the results of an investigation which was made in the summer of 1880, in connection with the inquiry made by Mr. Spear, into the occurrence of some fatal cases of disease amongst woolsorters at Bradford. Some of the more important facts brought to light by these investigations were embodied in Mr. Spear's Report, published in the Annual Report for 1880 of the Medical Officer of the Local Government Board.* But there remained a considerable amount of microscopic and experimental work to be done before the present report could be made, and, before it could be finished, other duties devolving upon the writer intervened and prevented its completion. To avoid the risk of further delay, it has been thought best to produce the report in its present crude form, embodying as it does the principal facts, rather than to wait for the opportunity of discussing them in more detail.

In order fully to understand this report, it is needful to read it in connection with that of Mr. Spear, in which the chief facts known with regard to the disease and its distribution are recorded.

What was known when the inquiry was set on foot was that a rapidly fatal disease, supposed to be due to the inhalation of particles of wool dust, occurred from time to time amongst sorters of wool; that those chiefly affected were the men who had to do with certain kinds of mohair. And it was beginning to be suspected, had indeed been suggested by Dr. Bell, that the disease was in reality a form of blood poisoning, and might be anthrax.

It was to solve this question that I was requested to make some pathological observations at the Brown Institution.

The result of these observations was to show that the disease, so far as could be concluded from experimental inoculations of animals, and from the microscopic anatomy of the organs, and other grounds, was identical with the common anthrax of cattle. Further, it appeared almost certain that the affection was in most cases produced by inhalation of the virus, and that its peculiar characters, which had led to the view that it was a form of bronchitis or pneumonia, were due to the mode of entry of the virus and to its effects upon the bronchi and bronchial glands.

It was then intended to show in this report by the record and discussion of these observations:—

1. That the blood and certain fluids and tissues of the body in these cases contained an organism having all the characters of the bacillus anthracis.

2. That inoculation of rodent animals with these fluids, when in a fresh condition, produced effects identical with those produced by inoculation with the blood of animals dying of splenic fever, these effects being death in a similar brief period, the presence in the blood of the anthrax bacillus, which could be successively inoculated in other animals, and when cultivated presented the same phenomena under cultivation as the ordinary anthrax bacillus.

---

* First Supplement to the Tenth Annual Report of the Local Government Board.

3. That the organs of the inoculated animals when examined microscopically showed lesions similar to those seen in animals dying from inoculation of anthrax. The sole difference observed was in one case the special degree of affection of the lungs as compared with other cases.

4. That the microscopic examination of the various organs of the human subjects of the disease showed conclusively that the affection was, in most cases, primarily a local one, affecting the bronchi and the bronchial glands. Here all degrees of affection were found, and the bacilli were present constantly and in great abundance. The disease was most marked near the bifurcation of the trachea and in the large bronchi, presenting itself as a diffuse mycosis of the mucous and sub-mucous tissues, with a variable degree of catarrh and ecchymosis. Extending thence, either directly into the mediastinum, and causing mediastinal cellulitis, or by way of the bronchial glands, producing in them intense lymphadenitis and hæmorrhage, the disease caused a serous effusion into the pleuræ, partly inflammatory in origin, but probably mainly dependent on the acute obstruction to absorption through the mediastinal glands. Together with this, other lesions were found in various parts of the body, differing in different cases, due to the general effects of the blood-poison.

In order the more fully to elucidate these and other less important points in the history of the disease it was intended to discuss and illustrate somewhat fully the morbid anatomy of anthrax in the lower animals, and of the external local affection, *malignant pustule* in man. At the present time the knowledge on these subjects has become so much extended and diffused that the failure to accomplish this portion of the report is the less to be regretted.

In the plates which accompany the report the more important points in the microscopic anatomy of the disease will be found figured and illustrated.

It will be convenient in the first place to give in some detail the evidence upon which the conclusions already stated are based, and to describe the experimental and other researches which were undertaken with a view of throwing light upon the subject, whether they yielded any positive result or no.

This evidence (apart from that afforded by the investigation conducted by Mr. Spear) falls under the following heads.

I. The microscopic examination of the fluids and tissues of the body in a recent state, together with experimental inoculation of the lower animals, and their results.

II. Microscopic examination of the organs from cases of the disease. The latter also serves to elucidate the mode of entrance of the poison of the disease, and the pathology of its symptoms.

III. The examination, microscopical and experimental, of substances (wool and hair, water, &c.) supposed to be the immediate source of infection in cases of the Bradford disease.

SECTION I.

Examination of and Inoculation with Fluids, &c.

The microscopic examination of the fresh fluids has already been detailed in Mr. Spear's report in connection with the case from which each specimen was derived, but it will be convenient here to repeat the chief facts in connection with the experiments made with the fluids.

Case I. (Case 20, p. 113, Mr. Spear's Report.)—T. C. æt. 71, died May 21st, 1880, at 3 a.m. Post-mortem examination made 30 hours after death; fluids received at 4.30 a.m. May 23rd, and examined between 5 and 7 a.m.

The spleen and blood which had exuded from it had the odour and appearance of decomposition. Microscopically they contained a large number of bacterial rods, most of which measured from 5 to 8 μ, but many from 10 to 15 μ. Many of the smaller resembled both in size and shape large specimens of bacterium termo, but they were motionless. The longer rods were of larger diameter, blunt at the ends, and contained spores resembling those of bacillus anthracis. Some micrococci were also present.

Some fluid from the pleura contained numerous very long rods, which measured from 50 μ to 150 μ in length, straight or jointed; and many other shorter rods, which contained spores more or less completely formed. Fluid exuded from the lung also contained abundant long and medium sized rods, measuring from 1·2 to 1·8 μ in diameter.

Inoculations of guinea-pigs and mice made with these fluids 50 hours after death were entirely without result.

Case II. (Case 22, p. 98, in Mr. Spear's Report.)—M. C., æt. 30, died May 26th, 1880, at 11 a.m. Post-mortem examination made 23 hours after death. Fluids received May 28th, 5 p.m., and examined at once.

The *blood* was fluid, contained no coagulum, the red corpuscles were separate, the leucocytes agglomerated into masses. The red corpuscles appeared natural. On a prolonged examination of numerous specimens, only six bacteria of any kind were discovered. These measured from 6 μ to 10 μ in length; one was in movement, the others quiescent, but all had a like appearance. They did not grow when cultivated on the warm stage, and none showed any sign of spore formation. No micrococci were seen in any of the specimens examined.

On cultivation of the blood in aqueous humour, no bacilli, only numerous decomposition bacteria, were observed.

The *pericardial serum* contained numerous bacilli which measured from 8 μ to 20 μ in length, their average length being 12 μ; and diameter 1·2 to 1·5 μ. These had also the microscopic characters usually seen in anthrax bacilli, and in many of them spores had been formed. Some were granular, as if in process of decomposition. A few free spores were seen. Together with these motionless bacilli, a number of common bacteria in active movement were present; these measured on an average from 4 to 6 μ in length, and about ·75 μ in thickness; they were in course of active division.

In the bloody fluid from the spleen were a few bacilli, which measured from 10 μ to 20 μ in length.

Inoculation with these fluids were entirely devoid of result.

Case III. (Case 11, p. 120, in Mr. Spear's Report.)—S. F., æt. 43, died May 5th, 1880, at 8 p.m. Post-mortem May 7th; fluids not received till May 12th, in capillary tubes.

The blood presented evidence of advanced decomposition, the red corpuscles being to a large extent destroyed through discharge of hæmoglobin. It contained large numbers of motionless bacilli, measuring from 10 μ to 25 μ in length, many of them containing spores; and also long filaments, from 50 μ to 60 μ long. Some of these bacilli appeared to be decomposed, as shown by the presence of numerous oily granules in the protoplasm. Scarcely any ordinary decomposition bacteria were seen in the specimens examined.

Inoculation with this blood 11 hours after death were entirely without effect, except in one case.

A mouse inoculated in the tail with a very minute quantity of the blood on May 12, at 1 p.m., was found dead on May 14th at 9 a.m.; it was examined at 3 p.m.; there was no local swelling either at the seat of inoculation or in the abdominal walls; the spleen was free from enlargement; all the viscera appeared healthy.

On microscopic examination, no bacilli were discovered either in any of the viscera or fluids of the body. In other words, death was not produced by anthrax.

With regard to these three cases, it may at once be remarked that the evidence afforded by these examinations is of no value in the decision of the question of their nature. If they were cases of anthrax, no successful result could have been obtained by inoculation with the fluids in the state in which they were received, for it is a well-known fact that decomposition, which was present in a very marked degree in all, almost invariably destroys the activity of the virus of anthrax, and prevents the development of the bacilli when introduced into the animal body. No certain conclusion can therefore be drawn from observations.

The next three cases form a group in which the nature of the disease was proved beyond doubt by the positive result of inoculations, and the successful result was due to the greater efforts to obtain and preserve the fluids at an earlier period after death.

Case IV. (Case 35, pp. 105 and 117 in Mr. Spear's Report.)—J. Bolton, æt. 36, died June 3rd, 1880, 4.30 a.m. Post-mortem nine hours after death; blood and fluids at once secured in capillary tubes, and received and examined 36 hours after death.

The *blood* from the *spleen* and portions of the splenic tissue appeared quite natural, and no bacilli were discovered in them, nor any other form of bacteria.

The *pericardial* and *pleural* serum were also natural and devoid of bacilli; only one or two micrococci (these possibly accidentally introduced) were discovered on prolonged examination.

The *blood* was fluid and of natural colour, the red corpuscles natural, leucocytes scanty, but those seen appearing quite natural. Scattered through the blood, but only in relatively small number, and for the most part in groups, were seen very long motionless bacilli, which varied in length from 50 μ to 200 μ, and their average diameter 1·5 μ. For the most part these were curved or flexuous, being thrown into folds by the movements of the fluid, otherwise quite motionless. Some appeared to be composed of two or more rods, joined at an acute angle. On examination after staining the blood with methyl-aniline violet, and also in dried specimens, and specimens treated with osmic acid, and in other ways, they showed the characteristic structure of bacilli, being composed of shorter blunt rods, united by a continuous external sheath. No spores were seen in any of the specimens examined, nor were free spores seen. With this blood the following inoculations were made.

Experiment 1.—A mouse (*a*) was inoculated in the tail with a very minute quantity of the blood at 4 p.m. June 4th, and died at 3.30 p.m. June 5th (23½ hours). The spleen was found to be swollen, and contained abundant anthrax bacilli. Bacilli were also found in serous exudation along the subcutaneous tissue extending from the seat of inoculation, and in the blood, &c.

From the spleen of the mouse (*a*) a guinea-pig (*A*) was inoculated with a very minute quantity, and was found dead 36 hours after. Its spleen was much swollen and contained abundant rods, which presented the usual characters of anthrax bacilli. From this spleen cultivations were made in aqueous humour, and these were continued through more than twenty generations, giving characteristic results on inoculation of the earlier generations, and presenting all the usual characters of anthrax bacilli. From the spleen of (*A*) another guinea-pig (*B*) was also inoculated, and died in 30 hours, with greatly swollen spleen, containing swarms of anthrax bacilli. From the spleen of this animal another (*C*) was inoculated, and died still more rapidly, with enormously swollen spleen, swarming with rods. Microscopic examination of the organs of these animals, after hardening, showed the most characteristic lesions of anthrax. The drawings of lung, Plate XL, Figs. 1 and 2, are from this guinea-pig.

Experiment 2.—Another mouse (*b*), similarly inoculated at the same time as (*a*), died during the night of June 5th, and was examined next day. The spleen was swollen, and contained a large number of anthrax bacilli.

Experiment 3.—Another mouse (*c*) similarly inoculated also died within 36 hours. The spleen contained only a very few rods, but in the blood of the heart were numerous long bacilli.

Two other experiments made with this blood may be mentioned here, for although they hardly come within the scope of this inquiry, they serve still further to illustrate the virulent character of the poison contained in the blood, and the fact of its identity with splenic fever.

Two heifers, one of which (*A*) had by previous inoculation been rendered to a large extent insusceptible of the disease, as had been shown by subsequent inoculations, whilst the other (*B*) had not been protected, were inoculated by subcutaneous injection, each with about 30 minims of the blood from this case.

In the case of *A.* only very slight local irritation was produced by the injection, not more than might have resulted from a similar injection of any fluid; in that of *B.* there was intense reaction, high temperature, great prostration, threatening death, and enormous local swelling, which extended in the quarter inoculated. In fact, in the case of *B*, symptoms were produced which were identical with those produced in other cases of inoculation with blood from splenic fever in the cow, and which had previously been induced in *A* in this manner, and protection thus conferred. Now we have no reason to believe that inoculation with splenic fever gives any protection against the inoculation with other animal poisons, and this experiment alone, apart from the more direct evidence given of inoculation of rodents, would have been a valuable confirmation of the nature of the disease.

Case V. (Case 30, pp. 102 and 118 in Mr. Spear's Report.)—J. Greenwood, æt. 48, died July 23rd, 1880, at 12 noon. Post-mortem examination at 9 p.m. Some blood which had been taken from the arm shortly before death was received at 3 p.m., July 24th, 27 hours after death, and examined at once.

Blood from the arm contained only a very few bacilli; these had all the ordinary characters of anthrax bacilli. The red corpuscles appeared natural; there were no other bacteria visible in the blood.

Experiment 1.—A guinea-pig (*D*) was inoculated at 3.30 p.m. with a very minute quantity of this blood in the inner side of the thigh,

and died at 8.30 p.m. next day (29 hours). There was marked gelatinous œdema of the subcutaneous tissue of the thigh and abdominal wall: no marked effusion in serous cavities; partial lobular collapse of lungs. The spleen was enlarged, and swarmed with bacillus rods. The drawing in Plate XII. is from the lung of this guinea-pig.

Other fluids, received at 9 p.m. July 24th, 33 hours after death, and examined, and inoculations made between 9 and 10 p.m.

Blood from the heart and blood from the spleen contained only a very few bacilli of typical characters; no other bacteria.

Fluid expressed from a bronchial gland, which was largely composed of blood, contained a few typical bacilli from 8 to 12 μ in length.

The pleural serum, which had been taken from the pleura eight hours after death, contained very abundant bacilli, which varied from 10 to 45 μ in length, some being as much as 150 μ long. These were in all respects like the filaments of anthrax bacillus under cultivation, in the stage preceding the formation of spores. In one tube there were masses of long convoluted filaments, arranged in spiral bundles and loops, exactly resembling cultivations of anthrax bacillus at a period of about 12 to 16 hours. Probably, indeed, they had grown to this form in the serum after enclosure in the capillary tube.

With these fluids the following inoculation experiments were made:—

Experiment 2.—A guinea-pig (*E*) was inoculated with the blood from the heart at 10 p.m. (34 hours after death of the man), and died at 3 p.m. on the second day, viz., 41 hours after inoculation, having had symptoms similar to those in the previous case. On examination the spleen was considerably enlarged (though less than in the animal inoculated with the blood from the arm); it swarmed with bacilli, and the general blood also contained them in abundance.

Experiment 3.—Another guinea-pig (*F*), inoculated at the same time, also from the heart blood, died in 48 hours, and presented similar post-mortem appearances.

Experiments 4 *and* 5.—Two guinea-pigs (*G* and *H*), inoculated with the fluid from the bronchial glands, also died, one in 38 hours, the other in 41 hours, and presented identical post-mortem appearances, both having a greatly swollen spleen, which swarmed with bacilli: gelatinous exudation in the subcutaneous tissue adjacent to the site of inoculation; and patches of lobular collapse and congestion in the lungs.

Cultivations in aqueous humour, made from the splenic blood of two of these animals, produced very typical growths of bacillus in successive generations.

The microscopic examination of their organs will be subsequently described.

Case VI. (Case 26, pp. 29 and 119, Mr. Spear's Report.)—J. Heaton, æt. 39, died August 30th, at 2 p.m. Post-mortem examination made August 31st. Specimens received and examined at 2 p.m. September 1st, 48 hours after death.

Blood from the spleen. This, which was mixed with fragments of splenic tissue, contained masses of felted filaments made up of short rods joined together. (*See* Woodcut in former report.) Many of the filaments were of great length. Around these bundles of filaments the tissue appeared much more transparent thna elsewhere, as if in a state of liquefaction, and all the blood corpuscles appeared to have become dissolved and broken up. In other parts the blood corpuscles and the constituents of the tissue appeared quite natural.

Fluid exuded from the lung contained very numerous bacilli, varying in length from 10 μ to 30 or 40 μ, and many much longer. Some of the shortest segments of the jointed filaments were only 8 μ long. Many of these bacilli were composed of one or more rods joined together at an acute angle. Many were long and sinuous; most showed some spores in course of formation or completely formed. Together with these bacilli were numerous red blood corpuscles, and large granular cells, some of which contained pigment.

In the pericardial serum no bacilli were discovered.

With these fluids the following inoculations were made:—

Experiment 1.—A guinea-pig, inoculated in the leg with blood from the spleen at 9 p.m. on September 1st (55 hours after death of the patient), died on September 3rd, at 12 noon, 39 hours after inoculation. When examined, two hours after death, there was considerable swelling extending along the thigh and over the abdominal wall, due to serous exudation in the connective tissue. The spleen was greatly swollen, measuring 3 centimetres in length, 1·5 in width, and ·5 in thickness. On microscopic examination it was found to swarm with masses of bacilli, scarcely anything else being seen in most of the specimens examined. In the other organs bacilli were also found in great abundance.

Experiment 2.—A guinea-pig, inoculated in the leg with bloody fluid from the lung at the same time as the preceding, died at 3 p.m. on September 4th, 66 hours after inoculation. When examined immediately after death, similar appearances were found to those in the previous case, but the exudation in the connective tissue planes contained more blood. The spleen was very greatly swollen, more than in the previous experiment, and contained very abundant masses of bacilli.

It will be convenient here to describe, by way of comparison, the results obtained by inoculation with the serum from a malignant pustule on the arm of a woolsorter (J. G., Case 40, p. 122, of Mr. Spear's Report).

A guinea-pig (α) inoculated at 10 a.m. June 24th with the serum, died on June 26th at 3 p.m. (53 hours). The symptoms and post-mortem appearances were precisely similar to those seen in the other cases, and need not be detailed.

A guinea-pig (β) was inoculated with a minute quantity of the serum from the thigh of guinea-pig α, two hours after its death (5 p.m., June 26th). It was found dead at 7 a.m on June 28th.

Two mice, inoculated in the same way and at the same time as β, were also found dead at the same time, all of these presenting the most characteristic appearances of anthrax.

Cultivations of bacillus from the fresh blood of the second guinea-pig β were also made, and a guinea-pig inoculated with the third cultivation died in 48 hours, presenting similar appearances with the preceding.

I shall not attempt to detail the appearances presented on microscopic examination of the organs of all these animals. They were similar to those seen in the case of animals inoculated from anthrax of cattle. Bacilli were present in great abundance in most of the organs, differing in proportion in different cases. The chief difference observed was in the relative proportion and arrangement in the vessels of the lungs. In some, the bacilli were scattered abundantly through the capillaries of the organ, in some parts much more numerously than elsewhere; in other animals they tended especially to accumulate in the form of masses in some of the branches of the pulmonary artery, forming thrombi in them, as seen in figs. 1 and 2, Plate XI. In these cases the capillaries

of the area of the lung tissue corresponding to the occluded arterioles also contained numerous bacilli, whilst the rest of the lung tissue was comparatively free.

In all the inoculated animals whose organs were examined, the lungs were found to be markedly affected. But from a comparison of this series of inoculations, with many others in which the anthrax virus was derived from other sources, I cannot say that any marked difference was observed. The differences which were observed may, I think, be fairly attributed to the differences in the freshness of the material used, and the relatively diminished potency of the virus.

SECTION II.

The Nature of the Local Lesion in Man.

It will be convenient next to describe the microscopical characters of the parts most visibly affected, and also of the other organs of the body. The evidence afforded by this examination has proved of very great importance in the elucidation of the nature of the disease, and of the mode in which the virus gains entrance to the system and produces its fatal results.

I shall at once dismiss from consideration the microscopic anatomy of three of the cases (Firth, Clee, and Crowther), for the organs when received were in such a condition as to be practically valueless for examination for bacteria, and shall refer only to three cases mentioned in the report Greenwood, Heaton, and Bolton, and to one case which has since occurred, viz. Oddy. The combined result of the investigation of these cases has been to show almost conclusively, that in at least a considerable number of the cases we have to deal with a disease primarily affecting the larger bronchi, and secondarily infecting the system by means of the lymphatics. This form might indeed be called malignant pustule of the bronchi.

On reverting to the detail of the post-mortem examinations given in Mr. Spear's report, it will be seen that in several cases there was a concurrence of the following conditions;—turgescence and vascularity of the mucous membrane of the lower part of the trachea and larger bronchi, which contained frothy fluid highly stained with blood, on removal of which spots of hæmorrhage were frequently seen; great swelling of the bronchial glands, these being sometimes completely broken down by hæmorrhage, and apparently transformed into blood-clots; extensive cellulitis, together with much hæmorrhagic effusion, around the bronchial glands and in the mediastinum generally; serous pleural effusion, often great in amount, pretty equally in both pleuræ, usually unaccompanied by any signs of pleural inflammation; a collapsed condition of the lungs. There might or might not be other concomitant conditions, but these were usually the most prominent, as they were the most constant. These conditions could not but arrest attention, both from their unusual nature and from the strong indication which they gave to one accustomed to trace the course of anthrax inoculations, that the virus entered at some point in the neighbourhood of the mediastinal glands, or draining through them by its lymphatics. Some cases seemed to lend colour to the supposition that the virus entered by the pharynx. But in all the cases in which I was able to make a minute examination, the trachea and bronchi seemed to be the site of chief implication. I shall, therefore, in the following description, take the condition of the trachea and bronchi as the starting point in the description, and range the other facts in relation to these.

Three selected cases, in which the affection of the bronchi was especially marked, will first be referred to in detail. These were the cases of Greenwood and Heaton, and that of Oddy, which has since occurred.

Case V. (30).—J. Greenwood. (For the full record of the post-mortem appearances, see Mr. Spear's Report, pp. 102 and 118.) The principal features observed at the autopsy as regards the trachea and bronchi, were that they contained a little blood-stained frothy mucus, and that there were numerous hæmorrhagic extravasations in various parts of the mucous membrane, especially at the bifurcation of the trachea. The bronchial glands were swollen, soft, and shewed hæmorrhagic foci.

Bronchi.—A more minute examination showed that there was very marked and irregular swelling of the mucous membrane near the bifurcation of the trachea, and in the larger bronchi, and that this extended as far as their second division, but not further. In the trachea itself no change was observed, except just at the bifurcation. In the bronchi the swelling was most marked in the second divisions, but it was very irregularly distributed.

On microscopic examination, both the trachea and bronchi presented in many parts the appearances common in chronic bronchitis. The epithelium had in great measure desquamated, the basement membrane was much swollen and thickened, and covered by an irregular layer of pyriform or irregularly-shaped cells derived from the deeper germinal layers of the epithelium. The principal recent changes were especially seen in the part immediately subjacent to the basement membrane. In this part, at the points where the hæmorrhagic extravasations were visible with the naked eye, it was found that the tissue was infiltrated with blood; the vessels greatly distended and filled with blood. At the margins of the clot, and lying here and there in the submucous tissue, were seen masses of bacilli. These masses were for the most part in the lymphatic spaces around vessels, lying alongside the vessels, and in no case situated within them. They were in fact no doubt situated in the lymphatic vessels which form a plexus in the bronchial wall.

The outlines of the lymphatic walls could not be readily traced, owing to the mode of preparation, but in some parts it could be distinguished, and in others the situation was constant and characteristic.

Around the parts in which these bacilli were scattered there were also seen evidences of intense inflammation in the tissues, but these were strictly localised; and in the larger lymphatics, where bacilli were seen, there was no sign of irritation.

These changes are well seen in the drawings in Plates VI., IX., and X.

Where complete sections had been made near the root of the lung, through the bronchi and the surrounding tissues, including some of the bronchial glands, the study of the condition of the bronchial wall and the tissue around it appeared to show clearly the course followed by the infection. As already stated, the bacilli were found in especial abundance towards the superficial parts of the mucous membrane, and appeared there to be arranged in an irregular and diffuse manner, but on going deeper they were found to be almost entirely in the lymphatics. At the muscular layer they had become very scanty, except here and there, where large masses lay in the lymphatics around vessels. Thence their course could

be readily traced along the course of the lymphatics to the bronchial glands, not continuously in any one section, but by noting the points at which masses of bacilli appeared in a series of sections. They were not observed in any other position than in the region of the lymphatics. No masses were visible in the blood-vessels. On nearing the bronchial glands some of the lymphatics were found to be completely distended with masses of bacilli; in some rupture had occurred, and there was inflammation in the surrounding tissues.

Bronchial Glands.—In the glands themselves it was in many places difficult to trace the exact position occupied by the bacilli, as the whole of the gland tissue was completely broken down by the blood extravasation, which extended into the surrounding tissues. But in some of the smaller glands immediately adjacent to the bronchi, the process was better seen. The lymphatics were in some parts quite plugged by masses of bacilli, whilst the rest of the gland appeared to be quite free from them. In those glands in which hæmorrhage had occurred, the bacilli appeared in some cases to occupy the venules in the cortical part of the gland.

Mediastinal Cellulitis.—The tissues surrounding the bronchial glands, including the connective and fatty tissue of the mediastinum, have already been noted as the seat of intense inflammation with a jelly-like exudation, often stained with blood or mottled with hæmorrhagic spots. The microscopic examination of these parts did not show anything very characteristic beyond the phenomena usual in ordinary cellulitis. Some of the connective tissue spaces contained large masses of fibrinous exudation, in which were scattered a very few bacilli. Here and there were found lymphatics passing through the tissue filled with bacilli, their course being marked out by the staining of the bacilli; but they were much more difficult to find than those in the immediate vicinity of and leading from the affected bronchi. The condition of the mediastinum was in fact exactly comparable to that seen in the connective tissue planes leading from the point of an artificial anthrax inoculation in the limb of an animal.

Before leaving this part of the subject it will be well to recall the fact that the fluid from the bronchial glands proved highly virulent on inoculation (*see* above).

Lungs and Pleuræ.—The condition of the lungs seen in the post-mortem examination was one merely of collapse, due to the great pleural effusion, and of a somewhat marked excess of pigment, such as is often seen in the lungs of persons of middle age, especially where bronchitis has been present. Microscopic examination served to confirm this observation. No marked recent changes were found except those due to collapse, and in most sections no bacilli could be discovered. In all the organs, it may be mentioned, isolated bacilli were found here and there in the sections of blood coagulated in vessels, but this was even less to be observed in the vessels of the lung than elsewhere.

Pleuræ.—No sign of inflammation could be discovered either in the superficial or deep parts of the pleuræ, thus lending support to the belief which is suggested by the condition of the pleural fluid, viz., that the effusion was not chiefly of an inflammatory nature, but largely of a passive nature, and due to the obstruction in the bronchial glands and the mediastinal cellulitis.

The presence of bacilli in the pleural serum, and the peculiar characters presented by them, have been already noted in the description of the fresh materials. It may be observed that the presence of the

bacilli in the fluid enclosed in the capillary tubes may very probably have been due to their accidental introduction from the blood or the mediastinal exudation at the time of the autopsy, and the subsequent growth in the serum, which acted as a cultivating fluid.

Case VI., that of J. Heaton (Case 28, pages 101 and 119 of Mr. Spear's Report), showed very similar lesions, but they were much more intense. Reference to the notes of this case show that marked symptoms were present only for 24 hours before death. At the post-mortem there were some swelling of the lower part of the neck, lividity of the neck, face, and hands. On removing the sternum there were seen an emphysematous condition of the cellular tissue in the anterior mediastinum, extending down to the subperitoneal cellular tissue, gelatinous exudation beneath the serous coat of the pericardium and upon its surface. In the pleuræ was a large quantity of clear serous fluid. The lungs appeared healthy, but collapsed. The bronchial glands presented hæmorrhage into their substance, causing breaking down of the tissue. The other organs showed no marked change. The trachea and bronchi, with the surrounding parts, were sent to me for examination unopened. In the lower part of the trachea, close to its bifurcation, and in the two main bronchi, there was very marked irregular swelling of the mucous membrane, which appeared in some parts to be infiltrated with blood, in others to be raised in hæmorrhagic bullæ. The lumen of the bronchi in the affected parts was very much narrowed, and on a transverse section the channel appeared very irregular.

Microscopic examination showed lesions which resembled those seen in the case of Greenwood, but were much more intense, and their mode of development could be much more readily studied in its various stages. The changes in the trachea were confined to its lower part, and resembled exactly the changes in the larger bronchi.

On examining the transverse section of a bronchus with a low power, the most marked change seen was the hæmorrhage into the mucous membrane. The remainder of the structure appeared in many places quite healthy. Examination with higher powers revealed other more extensive changes.

In the least affected parts, *i.e.* in those in which no hæmorrhage had as yet occurred, the mucous membrane was found to be here and there infiltrated with bacilli, these lying for the most part in a layer in the superficial part immediately subjacent to the basement membrane, or in clumps here and there in a similar position. In these parts the bacilli seemed to be as yet only accompanied by a very slight degree of inflammation.

The next step in the process appeared to be found in those parts in which, together with the presence of bacilli, there was a thin layer of hæmorrhage in the same region; beneath the basement membrane the epithelium remaining in situ and being almost unaltered. At the same time the bacilli are found to be increased in number and to penetrate more deeply into the mucous membrane, clumps being found in the deeper lymphatics.

Still later the hæmorrhage had greatly increased in extent, the epithelium was partly detached in a more or less continuous layer by the exudation of blood and serum beneath it, the mucous membrane was found to be largely converted into a mass of blood, infiltrating as deeply as the inner fibrous coat, or sometimes as deep as the mucous glands, but rarely extending as far as the cartilage. In the vicinity there were signs of commencing inflammation, but in no case had this reached any advanced degree. The bacilli in the superficial layers had now become much more abundant, forming dense masses, whilst in the lymphatics they were also

very numerous, forming, in some cases, complete plugs, in others nearly filling the channel. They could also be traced more deeply throughout the bronchial walls.

These changes can readily be traced by means of the drawings in Plates V. and VII.

(It must be observed that it was found impossible to represent the dense masses of bacilli so as to reproduce them in the lithographs, and it was necessary, therefore, to make them appear much less dense than actually seen under the microscope.)

Bronchial Glands.—In the bronchial glands and the tissue surrounding them the condition was similar to that in the preceding case, but the hæmorrhage was found to be much more extensive. In some of the glands the blood had entirely destroyed the structure of the gland, and both within and around the capsule was seen nothing but one mass of blood, with fibres representing part of the structure here and there. Very few bacilli were to be discovered in these glands, which were completely broken down; it appeared as if they had been washed away or displaced to the outer part of the clot, where they were found in small clumps. Compared with the masses seen in the bronchial mucous membrane, they were very scanty.

Lungs.—In the lungs were no very marked changes beyond those which would naturally result from collapse, and from the condition of the bronchi. Large areas of the lung tissue were examined with no definite result. Even in the immediate vicinity of the root of the lung there was almost no change to be found; a few scattered bacilli being found in some air vesicles, apparently inhaled from the bronchi with the bronchial secretion.

The term "fluid from the lung," used in the report of the autopsy, had reference to fluid partly expressed from the bronchi, which naturally contained numbers of bacilli.

Heart.—In the heart no marked changes were found; the muscular tissue appeared healthy. No bacilli were found except such as were seen here and there in sections of blood in vessels, as in other organs.

In the other organs only a negative result was obtained, no bacilli being found except on examining a large number of sections, when one or two were found in the blood-vessels. In the kidneys there was marked cloudy swelling of the epithelium of the convoluted tubules. In the spleen bacilli appeared only in comparatively small proportion; some were found in the bloody fluid expressed from it when fresh; but for the most part, the condition of the other viscera was only such as may frequently be met with in fevers.

The other case in which this bronchial form of the disease was especially well marked was that of W. Oddy, for the notes and material of which I am indebted to Dr. Bell, of Bradford.

The notes are as follows:—

"Samuel Oddy, aged 45, woolsorter. From January 11th, 1881, to "February 14th, sorted unwashed Van mohair locks, some of which were "very bad and dusty. The month preceding his fatal illness he sorted average "Turkish mohair. For several days before leaving off work he had not been "so well as usual. On Sunday, March 13th, 1881, he did not complain. On "Monday he was at work, but was not well; had no appetite. On Tuesday "he was worse, and gave up work at 4.30 p.m.; went home; did not com-"plain of anything; could not eat his dinner; went to bed and had a cup of

" tea. His wife did not think much of this, as he had done the same on " several previous occasions. He said that if he was left alone he should soon " be well again. About 7 p.m. he vomited, was chilly, and complained of " pains in the head. During the night he had very little sleep, was thirsty, " had slight cough, but no expectoration, and complained of pain or oppres- " sion across the chest, and could not get warm. On Wednesday, March 16th, " he still complained of pain in his head and chest, but did not think himself " seriously ill, and would not have a doctor sent for till the evening, when he " was seen by Dr. Rutherford at 8 p.m. His pulse was then almost imper- " ceptible, temperature under tongue and in axilla 94·7°, respiration 30. He " was ordered hot applications externally.

" I saw him at 12 midnight with Dr. Rutherford; he was then pulseless; " skin moist, cold; hands, ears, and neck livid; blood stagnating, arms and " legs cold. Respirations 46, some cooing sounds, puerile respiration, no " crepitant râles. Temperature in axilla 99·2°; in rectum 104·2°. Mind clear. " Tubes of blood were taken from the ear and finger. He died two hours " afterwards, at 2.30 a.m., March 17th, 1881.

" *Post-mortem examination* 14 hours after death. Body muscular and well " nourished. Face livid, ears blue-black, neck and infraclavicular region, " purple; front of body from nipples to pubes of natural colour; glans penis " and upper surface of scrotum dark purple; ends of fingers livid. On open- " ing the body, fatty tissue one inch thick, muscles dark coloured; no fluid " noticeable in abdomen.

" *Chest* opened. Anterior mediastinal space contained bubbles of air. Front " of *lungs* appeared natural, but on raising middle lobe of the right lung a " gelatinous mass of lymph was seen between upper and middle lobes. " *Right pleura* contained three pints of yellowish-green fluid. *Right lung* " crepitant throughout. *Left pleura* contained two pints of fluid; slight old " adhesions at apex. *Left lung* natural.

" *Bronchial glands.*—*Right* enlarged, dark coloured, soft and breaking down " when cut into. *Left* bronchial glands natural.

" *Bronchial mucous membrane* not injected nor stained." (This refers to the mucous membrane of the bronchi within the lung. The condition of the larger bronchi will be described later.—W. S. G.)

" *Heart.*—On removing, a large quantity of thin, dark-coloured blood flowed " out. Left auricle contained no clot; not stained. Left ventricle empty, " not stained. Mitral and aortic valves natural, no ecchymosis nor staining. " Right auricle and ventricle free from clot and staining; valves natural.

" *Spleen* not enlarged; of natural firmness.

" *Kidneys* natural.

" *Liver* natural."

Bacilli were found by Dr. Bell in the pleural serum, the pericardial serum, and in the blood from the heart. The lymph effused between the upper and middle lobes of the right lung was found to contain very numerous bacilli. Inoculation of a mouse with the blood from the ear, taken before death, caused death in 73 hours; and Dr. Goyder found very numerous bacilli in the spleen.

The parts sent to me for examination included the trachea and large bronchi, and mediastinal and bronchial glands, together with portions of various organs. No inoculations were made, as no sufficiently fresh blood was forwarded. My attention was specially directed to the condition of the air-passages and bronchial glands.

The examination of the bronchi and surrounding parts showed the presence of lesions in every way corresponding with those in the two preceding cases, especially that of J. Greenwood.

In the bronchi there was a similar condition of the mucous membrane, extending along the larger bronchi, in some parts similar irregular swelling of the mucous membrane, and hæmorrhagic extravasations. The bronchial glands were likewise swollen and the seat of hæmorrhage, and in some extensive extravasation had occurred.

Microscopically also the lesions were practically identical.

Bronchi.—*See* Plate VIII. The mucous membrane was in a condition of chronic catarrh, the basement membrane being much swollen. Beneath it, at the most affected parts, a layer of blood occupied the mucous and submucous coats, producing a swelling at the point. In the parts where hæmorrhage had not yet occurred, there were seen here and there clumps of bacilli; whilst at those points in which the hæmorrhage had occurred, there were masses of bacilli seen at the periphery of the hæmorrhage, and in the lymphatics of the deeper parts. Upon the whole, the process was not so intense in degree as in the case of Heaton.

Bronchial Glands.—The bronchial glands were, as before said, the seat of numerous hæmorrhages. But in many of them the blood-vessels were only extremely gorged with blood, and of varicose appearance; actual rupture not having occurred. As in the other cases, the bacilli were almost entirely limited to the lymphatics at their entrance to the glands, and to the lymphatics in the cortex. In some sections only one or two clumps of bacilli could be seen.

Spleen.—In the *spleen*, bacilli were only found in very small number, and no masses of them were observed.

Of the other organs, little need be said. As regards the presence of bacilli the examination, though very prolonged and minutely repeated on a large number of sections, gave practically negative results.

The *heart* was the seat of marked brown atrophy. The *liver* showed the changes common in chronic congestion of the hepatic venous system (nutmeg liver). In the *kidneys* there were corresponding lesions; and there was also a marked degree of recent congestion of the cortex.

Practically, therefore, the characteristic lesions were limited to the bronchi, bronchial glands, and mediastinal cellular tissue.

Case IV.—In the only other case in which the material sent to me was in a fit state for microscopical examination, that of Jacob Bolton (case 35 in Mr. Spear's Report), I did not, unfortunately, receive the bronchi or the bronchial glands. The conditions found at the post-mortem in these organs were closely similar to those in the cases just narrated; there were, namely, large extravasations of blood into the connective tissue of the mediastinum; the bronchial glands were swollen and hyperæmic. The mucous membrane of the trachea and bronchi was "injected," and the pleuræ contained each more than a quart of clear straw-coloured fluid. In both lungs were several apparently recent hemorrhagic infarctions at the superficial parts. (For the condition of the other viscera, see the post-mortem notes in former report.)

In regard to this case there must therefore remain some doubt as to the exact condition of the bronchi.

I was, however, able to examine the other parts through which it was supposed that inoculation might have been effected, viz., the tongue, pharynx, and most of the other organs.

The *tongue* showed no marked changes with the microscope.

The *pharynx* also, in the parts examined, appeared quite natural.

In the *lungs* only those parts were sent for examination in which there were hæmorrhagic infarctions. In these the pulmonary alveoli were simply distended with blood, in which long-continued examination failed to show any bacilli. The appearances were precisely those which would have been produced if hæmorrhage into a bronchus had occurred; there were no signs of local congestion or inflammation. So far as they go, they may be taken as suggestive of the view that some hæmorrhage had occurred into the bronchi, or they may, like the hæmorrhage in the

pia mater which was present in this case, have been due to some local cause.

In the other organs in this case nothing special could be discovered, the lesions being those of fever.

It must be remembered that, even in the blood of this case when examined in a fresh condition, only a very small number of bacilli were found, and it is always found much more difficult to detect them in microscopic sections if they are scanty and isolated. Moreover, in this case no bacilli could be detected in the spleen, the pericardial serum, or the pleural serum. When fresh, they must therefore have been very scanty in most of the organs. On the other hand, not only were they present in the blood, but inoculation of lower animals with the blood gave rise to a series of characteristic cases of anthrax.

Summary.

The conditions found in the three cases of J. Greenwood, J. Heaton, and W. Oddy may now be summarised :—

In all three the most striking features, already mentioned, were the coexistence of medastinal cellulitis, a greatly engorged or even hæmorrhagic condition of the bronchial glands, large serous effusion into the pleuræ causing collapse of the lungs, and last, though not of least importance, the presence of what may be termed multiple malignant pustules in the bronchi.

The lesion in the bronchi presented, in various degrees, constant and characteristic features, limited almost entirely to the lower part of the trachea near its bifurcation, to the two main bronchi, and in one case reaching to their first division; this lesion appeared as an irregular swelling of the mucous membrane, composed of rounded or irregular spots of hæmorrhage, which by their confluence produced more continuous masses.

By microscopic examination the stages of the disease could be traced.

In the earliest grade of the process, the most superficial layers of the mucous membrane are found to be infiltrated with bacilli, either as a continuous layer, or in small clumps here and there, not, however, in the blood-vessels. Later, they are also found in scanty clusters in the somewhat deeper layers, still, however, only in the connective tissue spaces or in the lymphatics, often alongside small vessels. Very speedily, however, there appear two other conditions, viz., hæmorrhage and inflammation; in all probability the hæmorrhage being in this case largely due to the intensity of the irritation which is produced by the bacilli.

When the hæmorrhage is slight, it may consist only of a delicate layer of blood extravasation into the sub-epithelial tissue, or perhaps between this and the epithelium, which becomes detached in a continuous layer. But if more intense, the extravasation may involve the mucous and even the sub-mucous tissue through its entire depth, causing a great swelling of the tissue. With the hæmorrhage are always found signs of inflammation, though in an early stage. There is also invariably in the vicinity of the hæmorrhage a much more marked accumulation of bacilli. They crowd the superficial layers of the mucous membrane of the affected regions, and are found in large numbers scattered in the connective tissue. Masses are found here and there in the lymphatics, and in some few specimens I have found them in the smaller vessels. In fact, they have not only undergone a great increase in number, but are penetrating the deeper tissues, and being carried by the lymphatics towards the glands. I may observe that this is almost the only instance I have found of exception to the general rule that hæmorrhages in

anthrax are dependent upon vessels plugged by bacilli, although of course it is probable that other causes may produce them, as in other forms of blood poisoning.

The changes in the epithelium are also of considerable interest. What is especially of interest is, that in the early stages the epithelium is entirely unaffected; there is not even the semblance of catarrh, as will be seen in some of the drawings; the ciliated layer is in perfect preservation. It is only later that it becomes affected; its nutrition is damaged by the processes which are taking place immediately beneath it; it may be detached in a layer by bloody or serous exudation; and then catarrhal and necrotic processes ensue. It also frequently happens that upon its surface is found a layer of catarrhal exudation mixed with blood, which may have been merely carried thither from more affected parts.

It is clear from the nature of these changes that there is no necessary antecedent bronchial catarrh; that the process of bacillus multiplication commences in the sub-epithelial part of the mucous membrane, and leads to changes closely analogous to those which occur in the skin in malignant pustule.

In the deeper parts of the mucous membrane there are, as I have said, masses of bacilli to be found in some of the lymphatics, without any surrounding sign of inflammation. In some specimens I have been able, where the bronchi were affected to further divisions, to trace these masses of bacilli, scattered at various intervals through the lymphatic plexuses surrounding the arteries, towards the bronchial glands.

The state of the bronchial glands will have been noted as a striking feature in two cases, and a similar condition is noted in many other cases. Great engorgement, scattered ecchymoses, or extensive hæmorrhage, transforming some of them into clot-like masses, or even rupture and extravasation into the surrounding tissues, are the observed conditions. Around these glands is constantly a condition of cellulitis, it may be with merely gelatinous straw-coloured fluid, or this may be blood stained, or largely composed of blood.

Even under the microscope the section of a bronchial gland might sometimes be mistaken for a blood clot, except that the sheath of the gland remains. Both within and around is seen an almost uniform layer of red blood corpuscles; only here and there small traces of gland tissue.

I have found but very few bacilli in this extravasated blood in any case, and none generally diffused through it. But in some of the small vessels, apparently venules, towards the periphery and outside the glands, masses of bacilli are constant.

In the lungs the changes are but slight. In those parts which are near the root, and through which the affected bronchi pass, there are inflammatory changes in the lung also, and bacilli are found in the lymphatics, but other marked changes I have not found. Early broncho-pneumonic processes are also seen, but not to a high degree.

Origin of the Bronchial Lesion.—One of the most important points in the inquiry is the determination of the relation which the changes in the bronchi bear to the disease; whether they are produced by the local inoculation of the virus in the bronchial mucous membrane, and constitute the starting point of the other changes observed. It is in my opinion difficult to resist the conclusion that such is the case, although I am fully aware that there are difficulties in the way of the acceptance of this view.

That this view is probable is indicated by the close analogy, almost approaching identity, of the process on the bronchial mucous membrane

with that in the skin in local malignant pustule, arising from external inoculation; by the absence of any other lesion at all corresponding with the other primary lesions with which we are acquainted; by the fact that here and here alone we have the presence of large numbers of bacilli in process of active growth and multiplication; by the fact that the bacilli are not found in the blood vessels in this part, but in the lymphatics, and can be traced thence to the bronchial glands by the lymphatics. And, lastly, that all the other changes could apparently be traced to this bronchial affection as a source. This latter point is one of especial importance, and upon it the proof must in great measure depend. To estimate it rightly, we must compare the changes with those which are produced by a local inoculation, whether accidental or intentional, in some part where the changes can be readily studied.

In the case of local inoculation in the distal part of the limb of an animal, we find that there is produced a very marked local swelling, extending from the point of inoculation along the connective tissue planes, and that the cellulitis sometimes spreads widely, and is often of a peculiar gelatinous character. In the fluid are always found bacilli. In the case of rodents, I have not found marked engorgement of the lymphatic glands, nor in bovine animals is this always prominent; but it appears always to occur in dogs and in man, and according to Toussaint's extensive experiments, it also occurs invariably in the sheep. In fact, in dogs and in man the process tends to be more local, and there is frequently formed a local lesion, the malignant pustule, which is surrounded by extensive cellulitis, and is always attended with marked inflammatory swelling of the lymphatic glands. It must also be observed that the cellulitis in all cases tends to spread very widely; that if the malignant pustule is seated on the forearm, the whole arm may swell up to a great size, the swelling extending both above and below the pustule; that if on the cheek, it may involve the whole side of the head and face and also the neck, and the cervical glands may become enormously swollen and engorged with blood; in other words, although the process of inoculation spreads itself by the lymphatics of the part, it tends also to diffuse itself somewhat widely in the adjoining tissues.

Now if we could locate a malignant pustule on any part of the mucous membrane of one of the larger bronchi, we should inevitably find that there would be rapid and great swelling of the bronchial glands, and by analogy we should anticipate an intense cellulitis around the swollen and inflamed glands, extending widely from the seat of the primary inflammation. This alone would serve to account both for the mediastinal cellulitis, and for its extension upwards to the root of the neck, and in some cases downwards into the sub-peritoneal cellular tissue.

Apart from any inflammation of the pleuræ we should expect some pleural effusion to result from this cellulitis, for both the lymphatics passing into the swollen or broken-down glands will become rapidly obstructed, and also the lymphatic trunks and veins themselves must be compressed, so that a dropsy of the pleura would probably result. If the pleuræ were generally adherent from old disease, we should anticipate the production of œdema of the lungs by the same mechanism. We have seen indeed, in one case, that the dropsy is not limited to the serous cavity, but may affect the deeper layer of the pulmonary pleuræ, and produce large watery bullae on the surface of the lung. As I have already hinted, this mode of production of the pleural effusion is indicated by its constancy in cases where this condition of the bronchial glands was present, by the equality of the effusion on the two sides, by the entire absence of signs of pleural inflammation both during life or after

death, and also by the characters of the fluid itself, and the absence of bacilli from it in some cases.

It may, then, on these grounds, be safely asserted that a primary lesion of the bronchi would be capable, so far as may be judged by analogy, of producing the conditions found in these cases.

Again, this view is not only supported by the position and character of the secondary lesions, but it is also consistent with the actual changes found in the bronchi.

It is well to emphasize here the fact that the changes found in the bronchi differ most strikingly from any secondary changes which I have observed either in man or in the lower animals; *i.e.*, secondary to some other known primary inoculation. For in all the positions in which I have examined these secondary lesions, *e.g.*, hæmorrhagic patches in the heart, the skin, &c., the bacilli have been found in the blood-vessels, or in positions which rendered it evident that they had been conveyed thither by the blood-vessels.

The parallel of the changes in the bronchi with those in malignant pustule of the skin cannot now be made, but is a very close one.

And, lastly, the great probability of inoculation taking place through the medium of the air-passages may be kept in view, and the absence in these cases of any other hitherto-discovered lesion of a similar nature in other parts.

Unquestionably there are certain difficulties in the way of acceptance of this view, which can only be stated here. These are—

First. The multiple character of the lesion in the bronchi themselves; if it is analogous with malignant pustule, it is not a single pustule.

Second. That the results of experimental inhalations do not indicate the mucous membrane of the bronchi as a probable position for the entry of the virus, the pulmonary alveoli being the usual absorbing surface.

Third. The presence in some cases of swelling of the glands of the neck at some distance upwards above the mediastinum may possibly indicate the position of the primary lesion as being at a higher point than the bifurcation of the trachea and the larger bronchi.

It will be necessary to consider these objections, and to inquire whether it is possible that the condition observed in the bronchi can be secondary before deciding certainly in favour of the view that the affection is primarily bronchial.

SECTION III.

Examination of the Hair and Wool, and direct Experiments with them.

It might have been anticipated that direct examination of and experimentation with the hair or wool which furnished the apparent source of the infection would have led to important results. This, however, as the sequel shows, was not the case, nor is the reason far to seek.

A consideration of the conditions of experiment affords a ready explanation of the causes of failure. So far as could be seen, the disease was originated by the inhalation of the virus with hair or wool dust from certain infected samples. From all the evidence attainable, these samples appear to constitute only a very small proportion of the wool; even when of the most dangerous kinds. And anyone who suffered from the disease would, during the period intervening between the exposure to infection and the occurrence of symptoms, have sorted or dealt with a large quantity of the wool. It might be that only one out of twenty

or more bags contained the virus, and that this was limited to one small part of that bag. When, therefore, it became desirable to take for purpose of experiment some of the wool supposed to be the source of infection, it would only be by a very fortunate chance that an actually infected part would be selected. The most likely material for experiment would be the wool dust collected from beneath the "table" at which the sorter had been working. Here, however, the dust is mixed with a large quantity of similar dust accumulated during some months (*vide* Mr. Spear's Report), and would, even if present, be highly diluted. Although the experiments *might* in these unfavourable conditions have been successful, they could not be negatively conclusive, if unsuccessful.

Another fact of importance was the difficulty, if not impossibility, of reproducing conditions analogous to those under which the infection occurred. If it had been possible to cause suitable animals to breathe constantly an atmosphere charged with the dust, the experiment might have succeeded; practically, however, the greatest difficulty was experienced in approaching these conditions.

From whatever cause, the entire series of experiments failed to produce any result.

For the purpose of examination and experiment, a large number of samples of the wool which was apparently the source of infection in the cases recorded, and of the "dust" from the tables of the sorters who died, were sent up by Mr. Spear. The results having been negative, I shall not give in full detail the record of the experiments, but merely their general outline.

Microscopic Examination of the Wool Dust.—This was found to consist largely of short fragments of hairs, to many of which parts of the rootsheath, or particles of epidermis, were attached. To many also there were adherent masses of altered blood clot. Many of the bits of hair were sharply pointed, and variously altered by decomposition, split up into fibrils, &c. Together with these remains of hair and epidermis, there was a large quantity of calcareous and other particles, and some vegetable matter, such as are found in ordinary dust; many fungus spores of various kinds; and in some specimens, a large number of a minute acarus. It was found impossible to distinguish any special spores or bacilli as related to anthrax bacillus.

Examination of the hair itself did not furnish any special information.

Experiments.—The first experiments were made by exposing two heifers to possible infection. One of these animals was supposed to be proof against infection, having been previously inoculated with anthrax; the other, as was proved by later experiment, was susceptible. The outbreak of splenic fever on the sewage farm at Harden having apparently shown that cows might be infected by water in which the hair had been washed, it was thought desirable to try a similar experiment. A quantity of the hair was therefore stirred into the water which the cows drank, and allowed to remain in the water, care being taken that it was thoroughly macerated. The cows showed some aversion to this water at first, partly, it seemed, because they swallowed some of the hair; but afterwards they drank it readily.

This was continued with fresh samples of hair for nearly three weeks without result.

Another method was then adopted, that of placing a quantity of the hair which was supposed to be most infected close to the food of the cows. Repeated samples were thus tried, every means being taken to expose them to infection, but also with negative results.

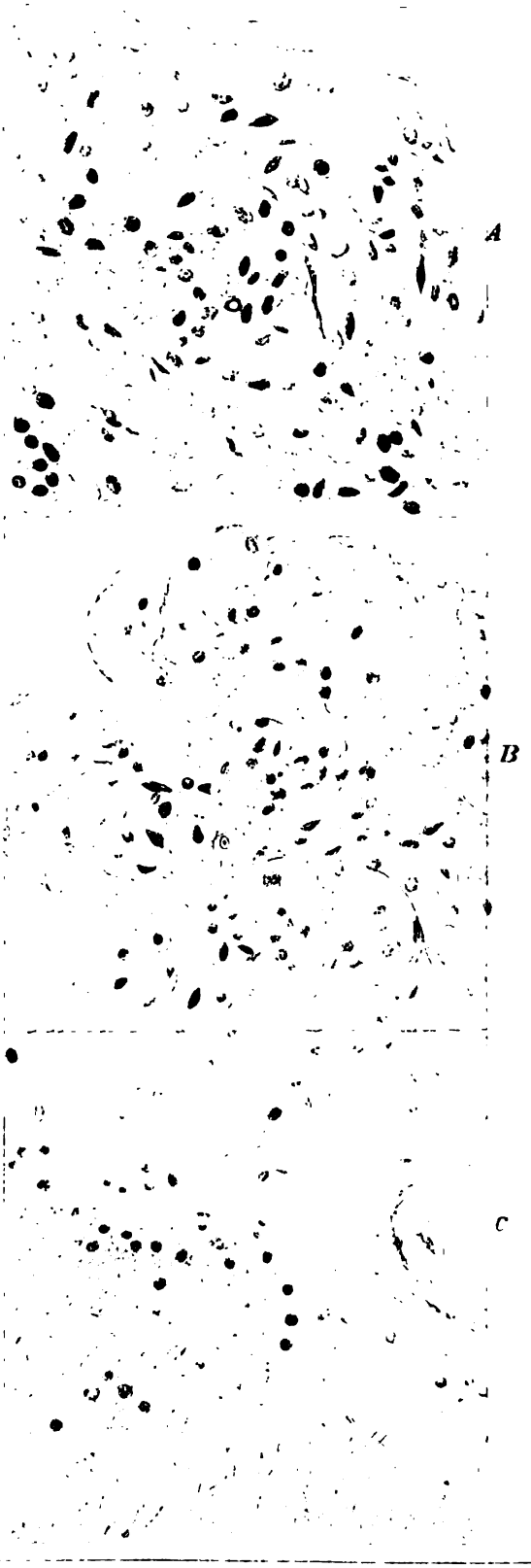
At the same time a number of experiments were made with guinea-pigs and mice. It was found on trial to be impossible at the time to keep the animals in an atmosphere charged with the dust. Had time permitted, it would doubtless have been found possible to overcome the mechanical difficulties which impeded the performance of the experiment. It was necessary, therefore, to trust almost entirely to feeding experiments.

For this purpose a number of guinea-pigs and mice were kept on food with which a large proportion of the wool dust, either as collected from the sorters' trays, or prepared by shaking out infected samples of wool, had been mixed. These feeding experiments, with varied samples of wool, were continued for some weeks, without in any case the slightest result.

These experiments do not in any way impair the belief that the wool was the source of infection, for apart from the difficulties to which reference has already been made, the experiments of others with material of known virulence have shown that these methods of experiment are liable to failure in a large proportion of cases. Buchner's inhalation experiments are especially interesting in this respect.

All that can fairly be said is, that the experiments, if successful, would have been of great confirmatory value; their non-success leaves the question to be decided by other means.

Examination of the soapy water from the Harden Grange tanks and trenches also gave entirely negative results.



DANGERFIELD LITH. 22 BEDFORD S^T COVENT GARDEN

EXPLANATION OF FIGURES.

PLATE I.—ANTHRAX (SPLENIC FEVER) IN BOVINE ANIMALS.—450 diam. From Drawings by Dr. Maddox.

A. Subpleural tissue from a cow which died of splenic fever, containing numerous bacilli.

B. Part of a renal glomerulus from the same case, showing bacilli contained in the capillaries.

C. Masses of bacilli in the heart. From a part of the heart wall in which rupture of a vessel filled with bacilli had occurred. At the lower part are seen the muscular fibres.

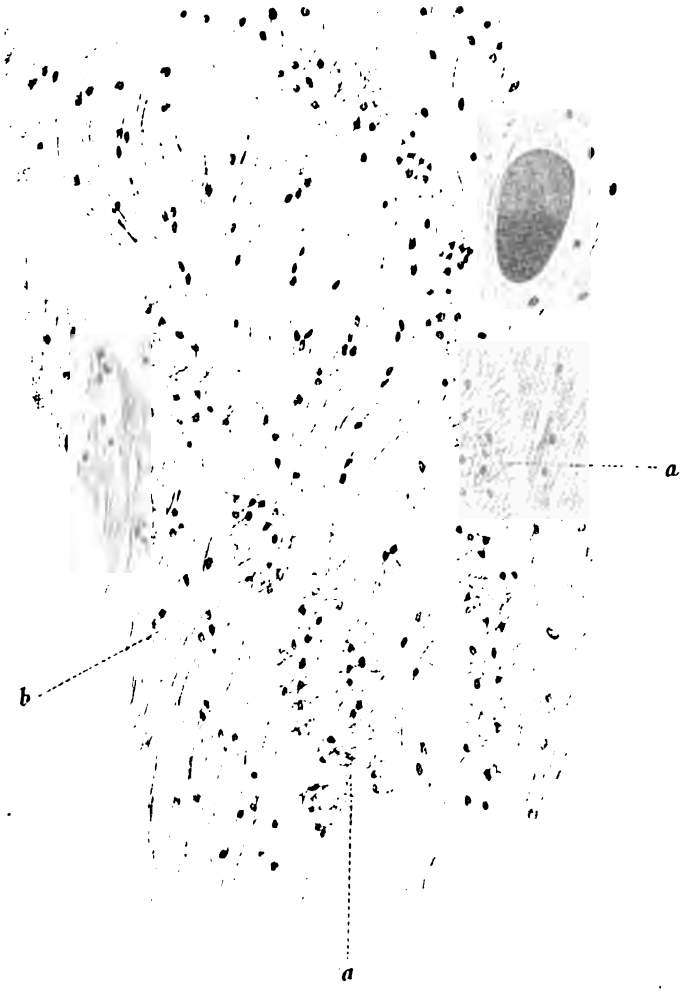
(In this and the succeeding plates the sections have been stained with methylaniline violet and mounted in Canada balsam. The outlines of the tissue elements are therefore for the most part indistinct, and in some of the drawings have been represented in a different colour for the sake of greater clearness.)

PLATE II.—Anthrax in Bovine Animals.

Part of the heart wall of a cow dead of anthrax produced by inoculation.

a, a. Masses of bacilli in the intermuscular planes of connective tissue. These had escaped from vessels in the immediate vicinity, which were plugged with masses of bacilli of such density that they could not be clearly represented in the drawing.

b. Muscular fibres.



Dangerfield. Lith 22 Bedford S.t

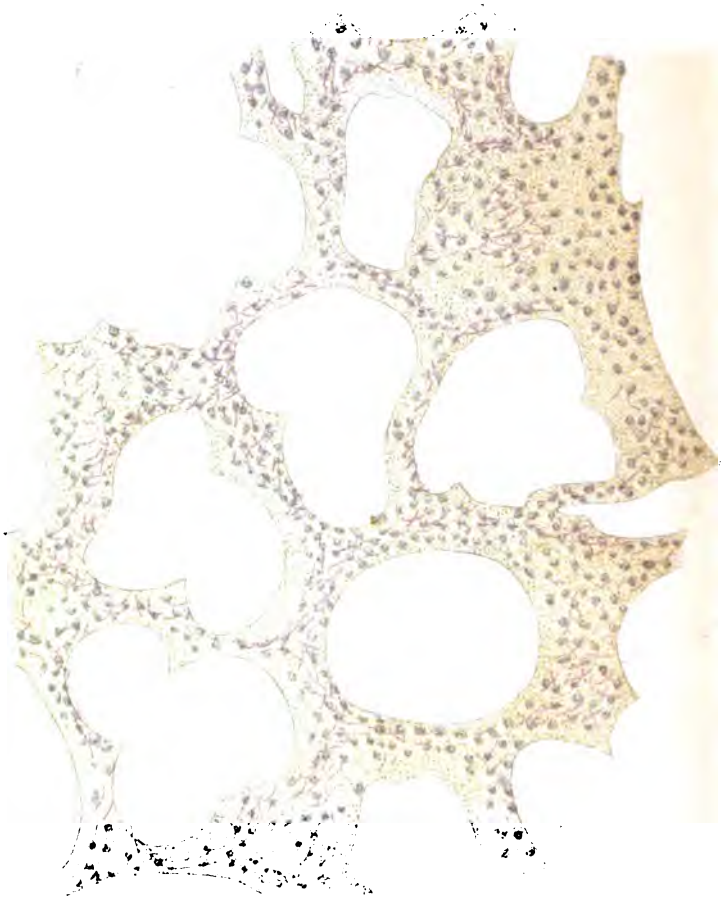


PLATE III.—Anthrax in Bovine Animals.

From lung of a cow dead of inoculated anthrax.

Bacilli are seen in great abundance in the walls of the air vesicles, being contained in the pulmonary capillaries, the outlines of which are not seen in the drawing.

From a drawing by Mr. John Grant, M.B.

PLATE IV.—Malignant Pustule in Man.

Fig. 1.

Section of entire pustule from the forearm of a woolsorter, magnified four diameters.

The limit of the pustule proper is between *a* and a^1, but the tissues beyond these limits are much swollen and elevated. Between *b* and b^1 is the central black eschar, consisting mainly of layers of altered blood with degenerated epidermic cells. At this level the tissues subjacent are deeply involved, the entire thickness of tissue seen in the section, extending deep into the subcutaneous fat, is infiltrated with blood and serum, and further to each side with leucocytes and blood.

Between *a* and *b* and a' and b' is the region of vesicles which are formed mainly by serous effusion in the rete malpighii, and detachment of the superficial layers of epidermis. This can be well seen between *a* and *b* on examination with higher powers.

Fig. 2.

Part of the same section under a higher power (400 diam.) showing bacilli in the lymphatics of the superficial layers of the corium. From a point between *a* and *b*, Fig. 1.

From drawings by Mr. John Grant, M.B.

Fig. 1.

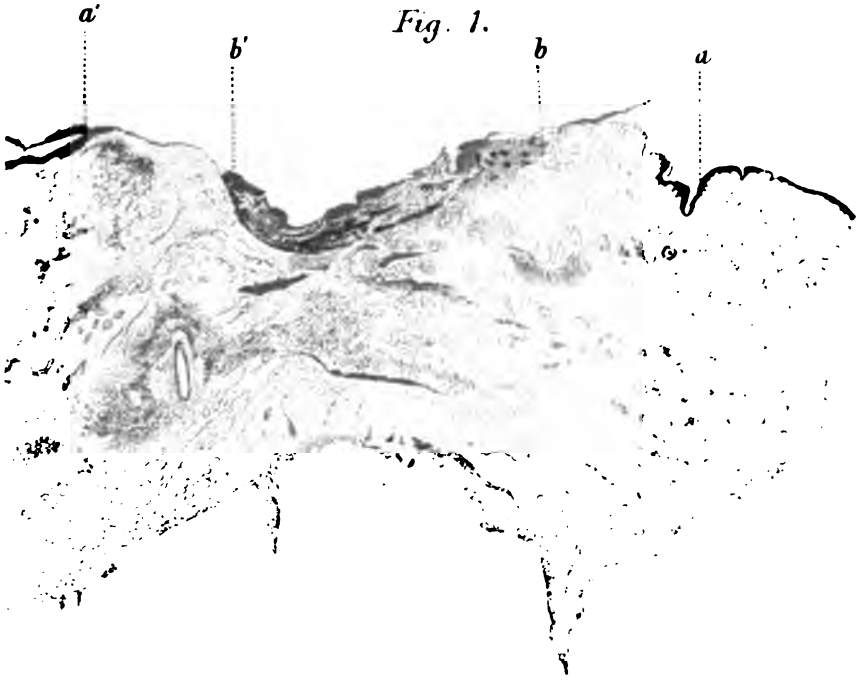
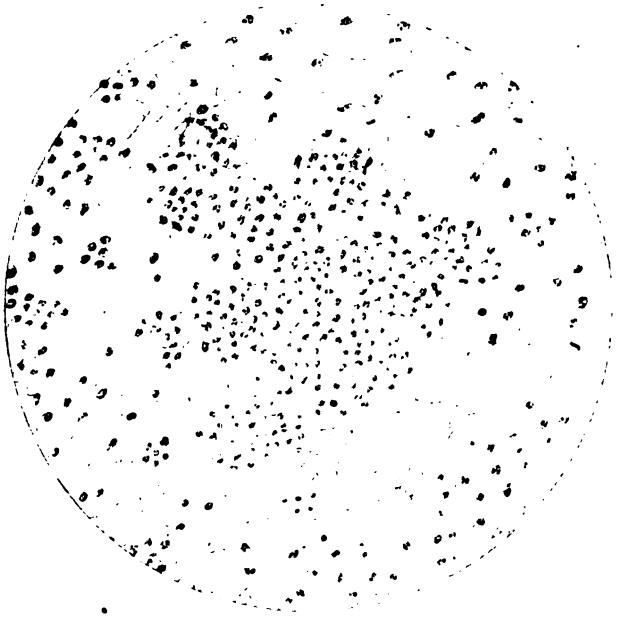


Fig. 2.



DANGERFIELD, LITH 22, BEDFORD S C

b
c
c
a
a
b
c

PLATE V.—Anthrax in Man (Woolsorters' Disease).

Section of large bronchus of a woolsorter (Heaton) stained with methyl-aniline violet, magnified four diameters, showing the irregular swelling of bronchial walls and hæmorrhage into mucous membrane.

a, *a*. Blood in mucous membrane, most distinct towards the surface, but infiltrating as far as *b*, *b*.

c. Cartilages, deeply stained by the colouring reagent.

Drawn by Mr. John Grant, M.B.

PLATE VI.

Bronchus of a woolsorter (Greenwood) under rather low power (about 50 diameters), showing an early stage of the bronchial affection.

a. Epithelium.

b. Mucous membrane infiltrated with blood and serum, and considerably swollen, forming a projection into the lumen of the bronchus. The normal thickness is seen to the left side of the drawing.

c. Glands.

d. Cartilage.

e. Position of the mass of bacilli mixed with blood.

Drawn by Mr. W. Anderson, F.R.C.S.

DANCERFIELD LITH 22 BEDFORD

Bronchus of a Woolsorter: J. Heaton.

Woolsorters' Disease.

DANCERFIELD LITH 22 BEDFORD ST COVENT GARDEN

PLATE VII.—Anthrax in Man.

Section of bronchus of a woolsorter (Heaton) showing under a higher power (about 120 diameters) the appearance of the mucous membrane at *a* in Plate V.

a. Epithelium, which is detached elsewhere.

b. A mass of blood infiltrating the mucous and submucous tissues, and containing numerous bacilli, some of which are seen at *f*.

c. Submucous glands.

d. Cartilage.

e. An amorphous mass consisting of altered blood and epithelium, and containing numerous bacilli; in structure and microscopic characters it closely corresponds with the central black eschar of the malignant pustule, *b*, *b'* in Fig. 1, Plate IV.

Drawn by Mr. W. Anderson, F.R.C.S.

PLATE VIII.—Section of Bronchus of a Woolsorter (Oddy).—Magnified about 220 diam. From a drawing by Mr. J. Grant, M.B.

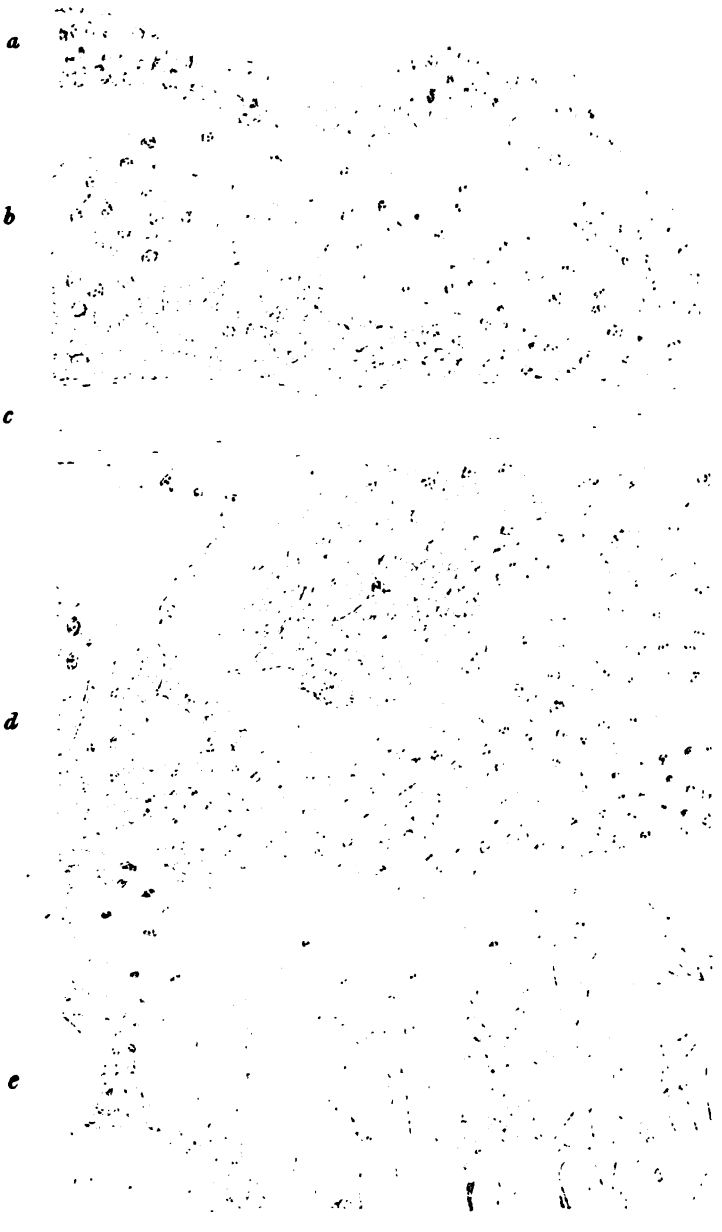
a. Epithelium, accidentally detached.

b. Mucous coat, which is seen to be slightly swollen, the capillaries distended with blood; at the deeper part is seen a mass of bacilli, which are situated around, but not within the capillaries.

c. Muscular coat, unaltered.

d. Submucous coat, somewhat swollen; capillaries greatly distended Numerous bacilli are seen in the tissue, around but not within the capillaries.

e. Mucous glands.



Dangerfield Lith 22 Bedford St

Bronchus of a Woolsorter (Greenwood)

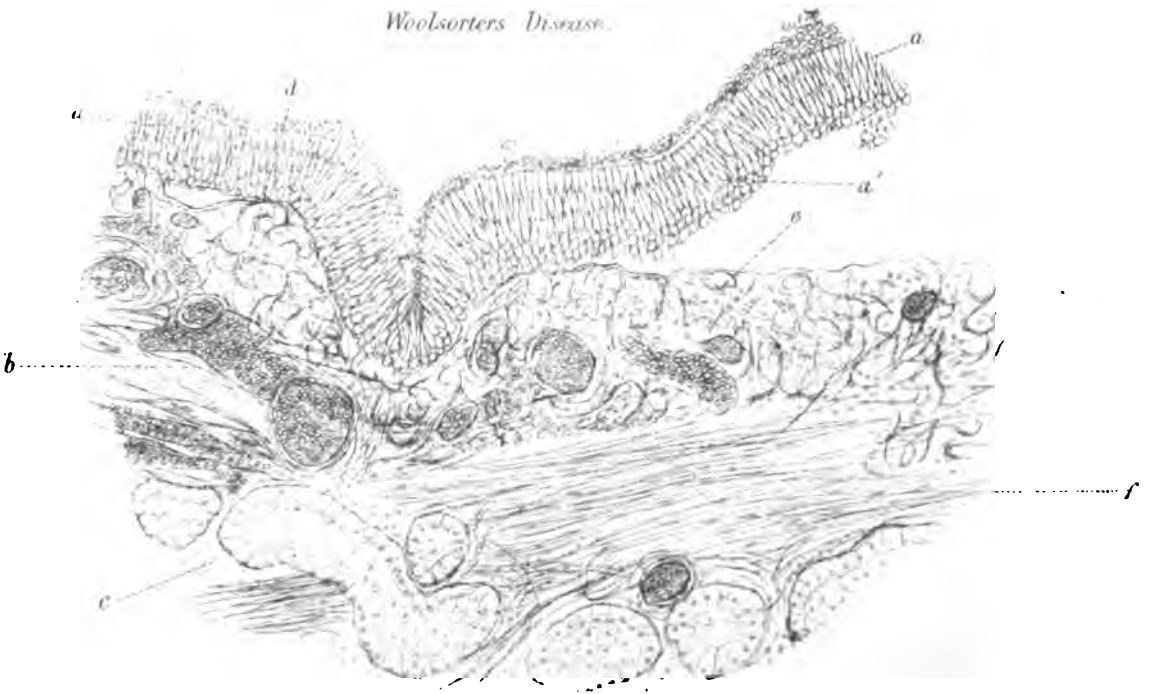


PLATE IX.—SECTION OF BRONCHUS OF A WOOLSORTER (Greenwood) SHOWING A VERY EARLY STAGE OF THE AFFECTION. (120 diam.)

a. Epithelium, covered on surface with a layer of blood corpuscles and mucous. The stratified appearance of the epithelium is mainly due to contraction of the bronchus. At *a'* is some proliferation of the deeper cells.

b. Capillaries and vessels of mucous membrane much engorged with blood.

c. Mucous glands.

d. A group of bacilli in the mucous membrane.

e. Bacilli in mucous membrane, occupying a distended lymphatic.

f. Muscular coat.

Drawn by Mr. W. Anderson, F.R.C.S.

PLATE X.—Bronchus of a Woolsorter (Greenwood).

a. Epithelium, beneath which is seen the basement membrane, somewhat swollen.

b. Distended capillaries in mucous membrane.

c. Mucous glands.

d. Cartilage.

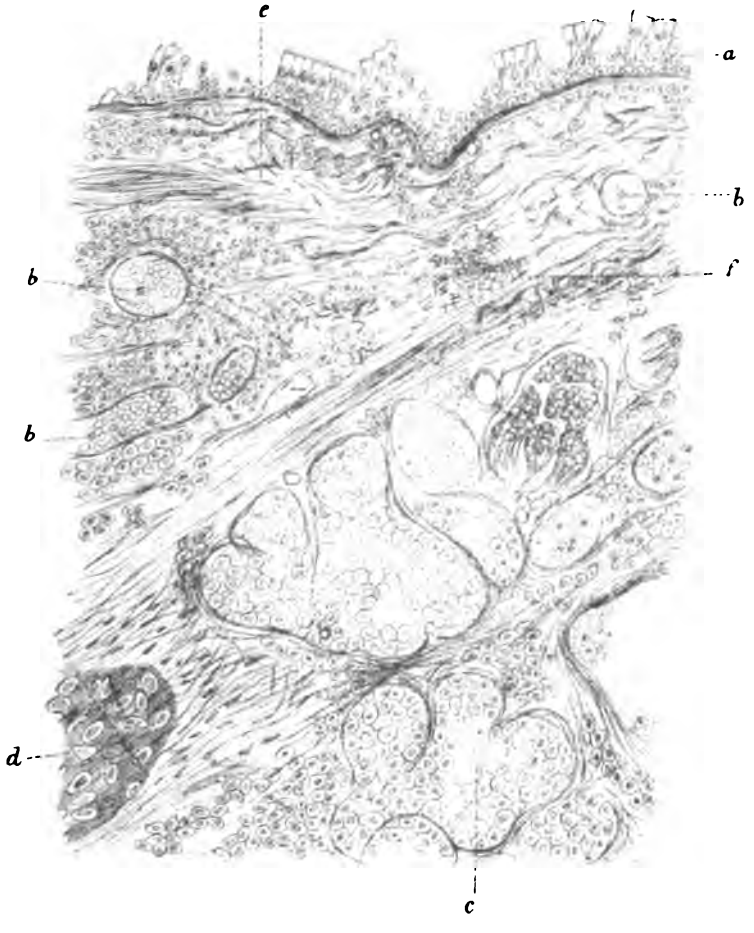
e. Scattered bacilli in superficial layers of mucous membrane.

f. A mass of bacilli in deeper part of mucous membrane, close to muscular coat.

Drawn by Mr. W. Anderson, F.R.C.S.

Bronchus of a Woolsorter. J. Greenwood.

Woolsorters' Disease.



DANGERFIELD. LITH. 22. BEDFORD S' COV

Fig 2.

Fig 1.

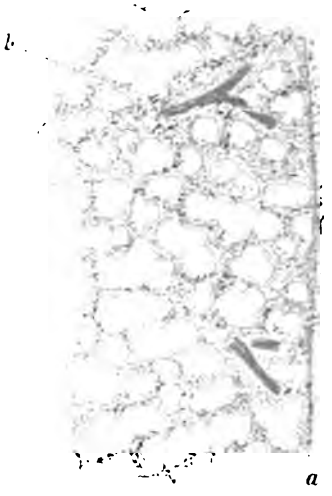


Fig 3

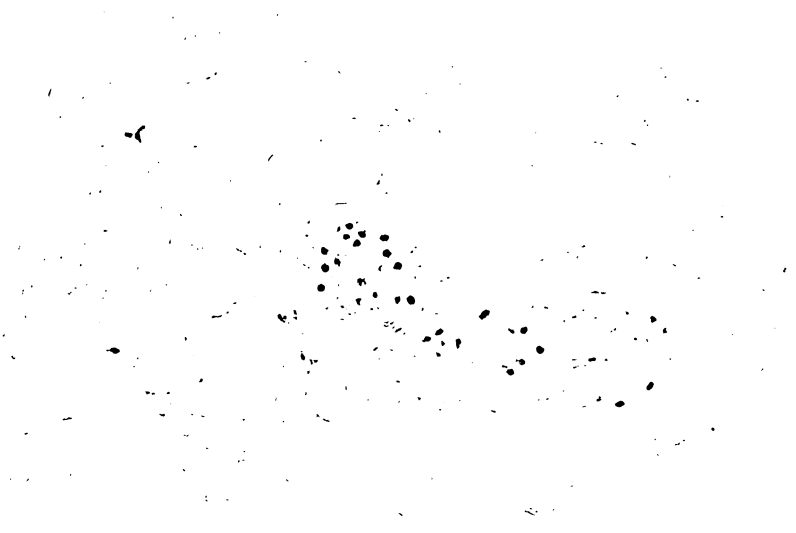


PLATE XI.—Results of Inoculation of Animals with Blood from Woolsorters' Disease.

Fig. 1.

Lung of a guinea pig inoculated with blood from woolsorter. Low power.

a. Pleural surface.

b. Masses of bacilli plugging branches of the pulmonary artery.

Fig. 2.

Mass of bacilli in an arteriole from the same lung, seen under a higher power.

Fig. 3.

Section of kidney, showing bacilli in the glomeruli, and in capillaries of intertubular plexus.

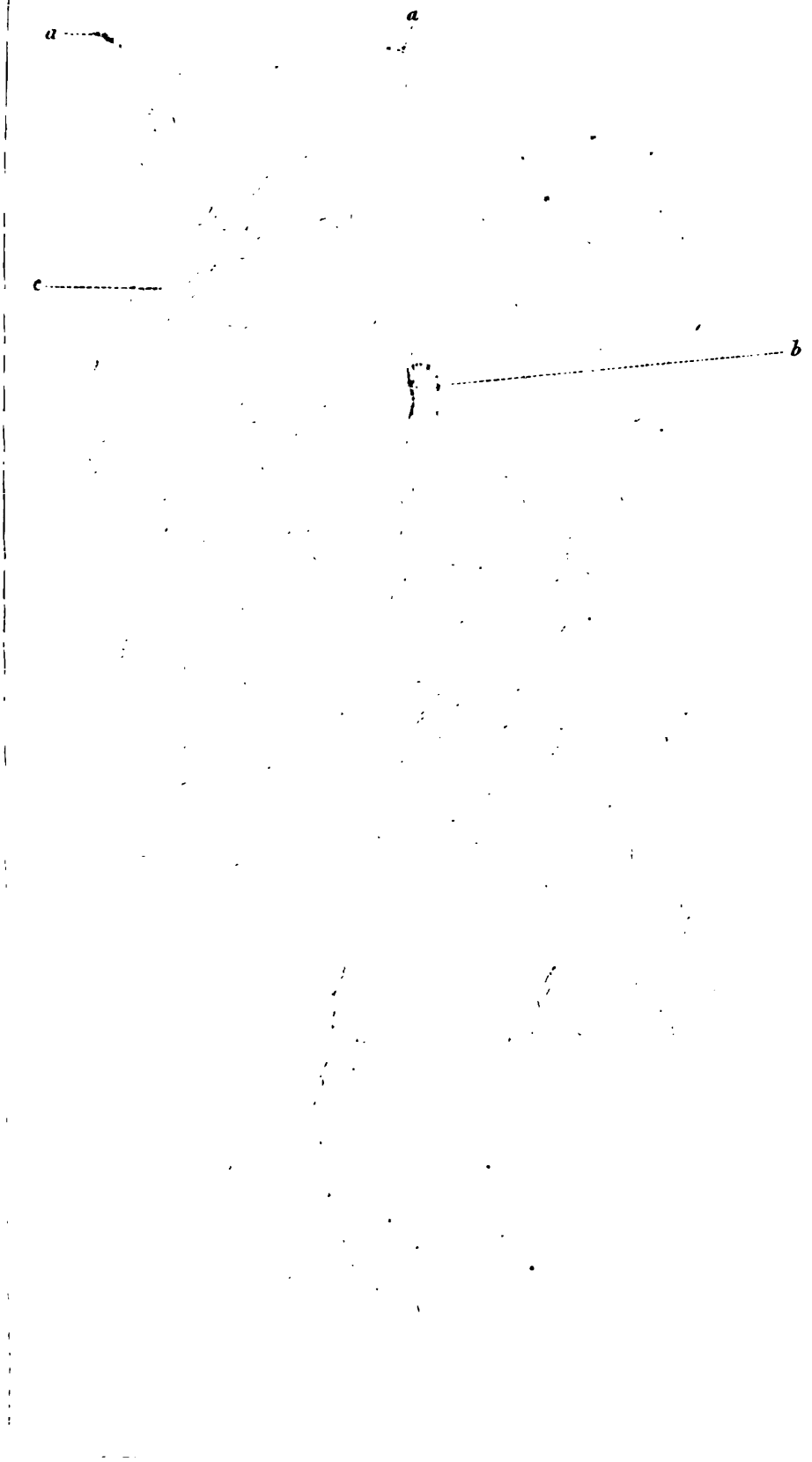
PLATE XII.—Inoculation of Animals with Blood from Woolsorters Disease.

Lung of guinea pig (D) inoculated with blood from lung of woolsorter (Greenwood).

a, a. Masses of bacilli in the deeper layers of pleura.

b. Mass of bacilli forming a plug in relatively large branch of pulmonary artery.

c. Bacilli in pulmonary capillaries in walls of alveoli, especially abundant near *c*, but also seen over the entire area of lung tissue represented.


a
a
c
b

No. 4.

On "Septic Bacteria" and their Physiological Relations; by Victor Horsley, B.S., M.B. (Lond.), Assistant to the Professor of Pathology in University College, London.

CONTENTS.

	Page.
I. Introduction	239
II. Presence of organisms in septic diseases	247
III. Life-history of septic bacteria:—	
(a.) Structure	250
(b.) Modes of development	252
(c.) Adult life — Chemical changes	253
(c.) Adult life — Physical „	254
(d.) Habitat — Under normal condition	255
(d.) Habitat — „ abnormal „	255
(e.) Action on (1.) dead tissues — Inorganic salts	255
(e.) Action on (1.) dead tissues — Organic compounds:—	
(α.) Fats	256
(β.) Albuminoids	257
(γ.) Carbohydrates	257
(e.) Action on (2.) living tissues — (α.) Modes of growth in	257
(e.) Action on (2.) living tissues — (β.) Changes produced in	260
IV. Septic intoxication:—	262
(a.) Nature of poison — (1.) Mechanical properties	264
(a.) Nature of poison — (2.) Physical „	264
(a.) Nature of poison — (3.) Chemical „	264
(b.) Dose, &c.	265
(c.) Effects — General	265
(c.) Effects — Local	268
(d.) Changes (in organs and tissues) produced by its action	268
V. List of "antiseptic" substances, in the order of their relative value	268
VI. Resumé	269
VII. Recent methods of investigating organisms	272
VIII. Bibliography	274

I.—Introductory.

The following Report, which was drawn up in the spring of 1882, has for its object to summarise the principal experimental facts bearing upon the physiological relations of the low vegetable organisms included under the term septic bacteria. In collecting the accumulated evidence on this subject, it soon became obvious that if the various results obtained by different investigations were indexed under two main groups, viz., the Life History of Bacteria and their probable Products, it would be possible to catalogue the facts, and thus afford a means of easy reference, although many generalisations would be sacrificed. With this end in view, the nomenclature and temporary classification of the lowest organisms are first described and then the details of their life history enumerated; while, as a second division of the subject, is placed the consideration of the chemical poison found in putrefying fluids, since it is the supposed result of the vital activity of these low fungi. From the present transition state of the subject of putrefaction and fermentation it was found necessary to exclude on the one hand evidence which rested on facts elicited by one or two observers only, and to avoid on the other hand all discussion of the close relationship, if not identity,

existing between the two processes. It only remains, therefore, in these introductory words to explain the meaning of some of the terms employed in the following pages. Thus the word *septic* (the substantive form of which is *sepsin*) is derived from the Greek root form ΣΑΠ as found in ΣΗΠΩ, ΣΑΠΡΟΣ, and which signified both putrefaction and fermentation (Liddell & Scott, Greek Lexicon); so that it really means a kind of katalytic (contact) process in which compound substances are broken up into simpler ones. The word septic is ordinarily understood to convey at the same time the idea of putrefaction, while the products of fermentation may neither be unpleasant nor poisonous. So far the terminology is clear, but the term *septicæmia* is at present used to mean both (1) a mycosis (that is, the invasion of an animal organism by a parasitic vegetable one) and (2) the symptomatic phenomena resulting on the introduction of the chemical poison of putrefaction (sepsin), this latter condition being also called sapræmia. To avoid this confusion it has been proposed to name the former condition septic infection and the latter septic "intoxication" or sapræmia. In view of the indefinite way in which the word septicæmia has long been employed, it would seem best to retain it solely as a general term, and thus it would have much the same meaning as the expression "blood-poisoning," in which sense it will be employed here.

The word "pyæmia" has long since lost its original meaning since research proved that the condition was not dependent on the presence of pus in the blood; so long indeed that it is now universally employed as a term under which a kind of systemic poisoning is accompanied by embolism, diffuse suppurative inflammations, rapidly varying temperatures and rigors.* Although this clinical picture may be incomplete, and thus one or more varieties of the affection be described, still the term may be retained as a general one indicative of a form of septic poisoning, the duration of which is usually lengthy and accompanied by the development of suppurative inflammation; the question of its mycotic nature will be discussed further on. Further, since it will be scarcely possible to avoid the use of the term "infection," or "infective," it is of the greatest importance to restrict its interpretation if possible, and to render our meaning clearer. Since, as we shall see, the chemical poison is exactly comparable to an alkaloid, we can scarcely speak of its action as in any way "infective" any more than the influence of aconite, &c. can be termed infectious. By infection, then, is meant a process connected with the life-history of some organism, and, so the term is applicable strictly speaking only to the conditions Nos. 2 and 3 of blood-poisoning, implying as it does the rapid spread and multiplication (within the animal) of the lethal cause.

(Note.—There is as yet no evidence pointing to the possibility of the chemical poison multiplying within the body.)

Finally, the word mycosis is used to signify the parasitic growth of a foreign vegetable organism in an animal, and although only as yet proved to occur in one or two diseases, it enables us to construct a theoretical schema of the possible causes of "blood-poisoning" or septicæmia. These are—

(1.) Absorption of the chemical septic poison (sepsin).

(2.) Invasion of the animal system by a rapidly growing organism, which by its growth and extension may interfere simply mechanically with the nutritive processes of the host. (Mechanical mycosis.)

* 6, 10, 16, 45, 46, 51, 55, 58, 63, 67, 70, 81, 25, 26, 33, 35, 88, 90, 95, 96, 103, 109, 110, 125, 134, 149, 165, 167, 176, 197, 199, 202, 214, 217, 224, 251, 259, 270, 275, 283, 286.

(3.) Poisoning of the system by the metabolic changes (*a*) destructive (*b*) formative, produced in it by the growth of a vegetable organism. (Biological mycosis.)

Thus in biological mycosis the animal may be killed in the first place by the destruction of its tissues, caused by the nutritive necessities of the parasite, or in the second place it may die from the metabolic products of the parasite's life.

From the consideration of the terms employed, we may pass on at once to the classification of the micro-organisms.

Classification and Nomenclature.—In the following description of the micro-organisms found in connexion with the katalytic process it is taken as proved that they are of vegetable nature, and so their classification commences under the head of the algæ. It is unnecessary to go further for proofs in this direction since all the details of their life-history (described below) establish their botanical nature, so that it only remains to see how far it is possible to classify the different varieties for the purposes of convenient description and future reference. The direct operation of their method of reproduction leaves it too open a question to accept the term "schizo" or "schisto" mycetes as expressive of all the varieties mentioned below, so in view of the temporary character of any classification merely the English expression for each chief variety has been retained. The method of classification of these different forms depends on the acceptance or rejection of the theory that all are mere metamorphotic states of one or very few stock forms. Where direct observation (and this only can be accepted as positive evidence on this point) has been applied to any given form there has been found a definite cycle of changes, resulting in a reproduction of the original shape; with the formation of filaments and spores as the only departure from the single rod with which the observation was commenced, the experimental evidence thus controverting the theories of Hallier and Naegeli.

Evidently then a practical classification, even though it be of a temporary nature, must be founded on other principles, such as form, &c. and the readiest is the older arrangement by Cohn, it being understood to be accepted merely for greater ease of description. The arrangement of the organism into tribes and subdivisions necessarily fails where apparently the same organism is found under opposite conditions, and then a functional difference is perforce assumed, to convey the idea of specific nature of the organism. The insecurity of such minuter description does not, however, militate against the practical value of the classification which with the reservation mentioned above will be employed in the following account. The classification as it stands then consists of four tribes and six subtribes.

Tribe I.—*Spherical Organisms.*

Micrococcus. Round or oval organisms, 1·5—2μ in diameter.

Subdivision.			
1.	M. prodigiosus (red)	Pigment insoluble, or very slightly, yellow soluble (244)	in water.
2.	M. luteus		
3.	M. aurantiacus	Pigment soluble	
4.	M. chlorinus		
5.	M. cyaneus		
6.	M. violaceus		
7.	M. ureæ.	Supposed cause of Urea katalysis.	
8.	M. vaccinae.	„ „	Vaccinia.
9.	M. diptericus.	„ „	Diphtheritic inflammation.
10.	M. septicus.	„ „	Suppuration, pyæmia, &c. (Klebs.)
11.	M. bombycis.	Mycotic cause of death in silkworms.	

Tribe II.—*Bacteria.*

Sub-division.

1. B. termo. Cylindrical organism with rounded extremities; length, 2—3μ; breadth, 1—1$\frac{1}{2}\mu$. Often united in pairs.
2. B. lineola (Cohn). Length, 2—7μ.
3. B. lactis (Lister).

Tribe III.—*Ribbon-shaped Organisms. Desmo Bacteria* (Cohn).

Sub-Tribe (*a*). Straight axis. *Bacillus.*

1. B. subtilis. Supposed cause of butyric katalysis; length, 6μ. breadth ·5μ, or less.
2. B. ulna. Length, 10μ, breadth, 2μ.
3. B. anthracis. Supposed cause of one form of splenic fever: length, average 4—5μ.
4. B. septicæmiæ (Koch).
5. B. malariæ (Klebs and Tommassi).
6. B. tuberculosis ? (Koch).
7. B. leprœ.

Sub-Tribe (*b*). Wavy axis. *Vibrio.*

1. V. rugula. With one flexure. Average length, 8—16μ.
2. V. serpens. With several flexures. Average length, 23—26μ. with 10—15 flexures.

Tribe IV.—*Screw-shaped Organisms.*

Sub-Tribe (*a*). Flexible and wide screw interval. *Spirochæte.*

Subdivision.

1. S. plicatilis.

Sub-Tribe (*b*). Stiff, with narrow screw interval. *Spirillum.*

Subdivision.

1. S. tenue. Length, 2—15μ.
2. S. undula. Larger size than S. tenue.
3. S. volutans. Largest S. Length, 25—30μ; thickness, 1·5μ.

Note.—Those conversant with Cohn's classification will note that in the above version the term bacteria is restricted to Tribe II. Since this has been done the growing tendency among the authors who have written on the point is to apply the word only to a cylindrical organism, the length of which shall not exceed twice the breadth, provided that the form under consideration is in the adult stage. Further, although measurements are given as diagnostic of each organism, these are not in any way to be considered as exact, since in every preparation forms of different length may be seen as a mere result of fission, but the figures are added to aid in the recognition of any given form.

With this sketch of the kinds of organisms met with under the name of septic "bacteria," we are now able to discuss their physiological relation and their distribution in health and disease.

The universality of distribution of the organisms numerated above, when considered in connexion with their supposed pathogenetic properties, renders it highly important to investigate further the details of such distribution. These details may be most conveniently studied under the headings of the Soil, the Atmosphere, and Water.

1. *Soil.*—It is only comparatively recently* that the study of organisms, the adult forms or spores of which are found in the soil has been taken up. The forms most commonly found are micrococci and

* 184.

bacilli, and, as might be expected, the superficial layers contain the greatest number; while further the bacilli are found, especially where the soil is saturated with decomposing animal and vegetable fluids (manures, &c.), the organisms decrease in frequency with the depth investigated, until at about 1 metre the undisturbed earth is apparently free from them.* In connexion with the existence of organisms in the earth, it must be remembered that (1) probably† the lowest winter temperature has not the slightest influence on their actual vitality, and that (2) the penetration of the soil by them will differ according to the possibility of carriage by the soakage of water: while some of the zymotic diseases are possibly mycotic in origin,‡ and are undoubtedly connected with obscure changes in the soil, the question of the existence of organisms in soil which may be termed healthy evidently requires thorough investigation, and would afford a firm foundation for the subsequent research into the etiology of cholera and malaria.

In passing from the consideration of the earth organisms to those found in the air, we necessarily discuss their occurrence in dust, since it is possible by filtration, &c., to obtain air dust-free and organism-free also. The possibility of organisms existing in the dust depends on several conditions, not the least important of which is the but slightly known subject of the duration of life when the organism is exposed to prolonged drying. Under these latter circumstances, at any rate in old dust on cultivation, only mould fungi and bacilli have been obtained, *i.e.*, vegetable forms habitually forming spores which are undoubtedly capable of greater resistance to various agencies, such as heat, &c., than the adult forms which are readily killed.§ Further, since the proportion of dust in the air varies greatly, it has happened that no organisms have been obtained from some specimens, while in other cases, such as the atmosphere of hospital wards, they are found in large numbers. In similar moist and warm air of rooms, micrococci as well as bacteria and bacilli, have been found and artificially cultivated. There seems to be an agreement in the experimental investigation of this question with regard to bacterium termo, spirilla, spirochæta, and a few others, viz., that they are but very exceptionally contained in the free air; and therefore, supposing the theory of organised ferments to be possible, the starting of putrefaction, &c., would be usually due to carriage of the ferment by other means than atmosphere.‖ Organisms are found in greater number in the air close in the neighbourhood of decomposing substances, and the purification of the atmosphere beyond is perfectly obtainable by the proper use of ventilation and disinfection.¶

Water.—The existence of micro-organisms in water depends of course upon the presence of the proper percentage of solids requisite for their nutrition, and whenever investigated under conditions which render their admission from the atmosphere impossible, this has been found to be the determining fact of their appearance or not. They have even been found in snow.‖

In generalising from the foregoing details, we see that the occurrence of these lowest plants depends entirely on the density of the medium in question, and that excess, either on the side of concentration or dilution, equally determines their non-development and (if previously introduced) their death. This point will be seen later on to be of universal truth, and whether the medium be river water or concentrated discharge from

---

* 134.
† 27.
‡ 132, 40, 229, &c.
§ 134, 187, 12, 57, 100, 105, 157, 163, 173, 182, 196, 222, 215*a*.
‖ 43.
¶ 173.

a wound, organisms are incapable of growth until concentration in the one case and dilution in the other has been performed.

From the consideration of the existence of micro-organisms outside the animal system, we pass on to the discussion whether the apparently universal distribution is equally true of the interior of the body. To take the regions most exposed to the air as the simplest case, we find that the skin and alimentary canal are the common seat of the growth of organisms. As regards the parasites on the exterior of the skin, it is to be noted that organisms have been frequently found in perspiration even when the skin has recently been cleansed, and that these organisms may present a yellow or blue colour. They have also been described as growing on and in hairs supposed to be healthy.* The colour of these parasites may be red, yellow, violet, or blue. The orifices of the alimentary canal and air passages are loaded with organisms of various forms, micrococci, bacteria, spirilla, spirochæta, and bacillus filament (leptothrix);† while they penetrate into all neighbouring cavities that can form a suitable nidus such as the dentinal tubules where exposed in carious teeth. With reference to the last point, it is interesting to notice that each canal or tubule contains but one kind of organism,‡ another evidence of the mode of growth described on page 241. As the investigation is carried further down the alimentary tract, micro-organisms become less and less frequent, so that it is doubtful if the healthy empty stomach contains any at all so to speak indigenous, especially as acids, even if very dilute, are so unfavourable to the life of organisms.§ Of course, quantities dependent on the character of the food are introduced at each meal, but save in pathological states of the mucous membrane the gastric secretion appears to be adverse to the vitality, or at least to the development, of these organisms; but some, of course, enclosed in undigested masses of food, may pass through the pylorus into the duodenum. Here they are subjected to the action of three secretions, the biliary, pancreatic, and that of Brunners glands. Of these, the first and third have probably no action on cellulose, and therefore the adult organism may exist and perhaps develope in entire fluid. On the other hand, pancreatic juice swarms with organisms on the least introduction of impurity,‖ and since indol is found in the fæces, it is fairly certain that they exist in the human duodenum. Further, since the secretion of the remainder of the alimentary tract is an alkaline fluid with but a slight amylolytic action, organisms may be found all along the intestines. In dependence on this fact lies the possibility of a micrococcal mycosis occurring in cases of ulceration of the mucous membrane, and enabling sufficient masses of organisms to gain access to the blood stream by means of the lymphatic spaces and duct, possibly accounting for some "pyæmic" conditions resulting on a severe attack of typhoid fever.

The entrance to the air passages we have seen to be the seat of luxuriant fungoid growth (especially in cases of disease or want of cleanliness), but according to the, as yet, scanty research on this point they are not found deeper than the divisions of the bronchi. And the alveoli are said to be completely free from them unless they are artificially introduced.** This is perfectly comprehensible when we consider the constant carriage outwards of the bronchial mucus by the cilia; and all organisms inhaled if not arrested in the pharynx are

---

* 76, 210, 116*a*, 19.
† 44, 168.
‡ 134.
§ 253.
‖ 186, 126, 239.
¶ 269.
** 286.

narrow chink of the glottis would apparently certainly be caught by the sticky lining of the bronchi, just as a tube coated with glycerine acts as a filter.

If, however, carbon particles are carried from the exterior of the body into the lungs and lymph glands by currents of air and white corpuscles, there is no reason why organisms should not enter the body by the same route, and so the question must be left open.* That they enter in disease is of course well known, the function of the mucous membrane being impaired.

The genital passages afford opposition to the entrance of organisms according as the surfaces of mucous membrane are usually in contact or not, and whether an intermittent outward stream of secretion exists. Thus in neither sex are organisms found at the proximal portion of the urethra, in which tube since both of the above conditions exist, it is only when a clear path is afforded by dilatation of the canal by pus, &c., that organisms are found deeper than the meatus. Under these and other circumstances the micrococci found in gonorrhœal discharge cannot be said with the present means of experiment to possess a specific property of exciting the inflammatory process in that case.

The forms customarily present are those enumerated above as occurring in the first part of the alimentary canal.

The presence of organisms in other external cavities and hollows, such as the auditory canal, navel, &c., varies of course with individual cleanliness and are identical with those found elsewhere on the skin and in the mouth.

So far the relation of these fungi to the exterior of the body is perfectly clear, but it brings us on to the next extremely important question: Do they penetrate into the interstices of the tissues? Unless we accept the possibility of their spontaneous evolution† from protoplasmic particles of the corpuscles, glandular or otherwise, already present in the body, the conclusion is inevitable that at least in pathological states they do enter the system by the alimentary canal, and then by the lymphatic system proceed to rest in the cell spaces, and possibly in the cells themselves. Particular stress is laid upon their entry by the above-mentioned route, since "purified bacteria" have been frequently injected‡ into the blood-stream, &c., in healthy animals, and no trace of them found at the end of 24 hours, moreover while organisms easily develope in other tissues, they do so with extreme difficulty in the blood,§ also *vide infra*, p. 246. But we have yet direct experiment bearing on this point, viz., the injection of organisms into the blood-stream of an animal, a portion of whose body is the seat of necrobiotic change.‖ Here the organisms undoubtedly leave the blood-stream and penetrate into the centre of the dying tissue, which forthwith undergoes putrefaction. (Note, the mixture injected contained decomposing albuminoids as well as fungi, but that of course only bears import on the question of decomposition and not that of the penetration by organisms.)

On these lines the now frequently observed occurrence of organisms in acute internal inflammatory foci¶ is at once accounted for; the sequence of events being probably, first the depression of the animal's system by faulty hygiene, &c., leading to general impairment of vitality and consequent easy invasion by vegetable organisms. The latter sentence implies that there is a struggle between the growth of the foreign organism and the vitality of the tissue, with the assumption

* 43.
† 12, 4, 15.
‡ 141, 115, 156, 214.
§ 22, 157.
‖ 52, 135.
¶ 17, 31, 191, 76, 22.

that the result is in favour of the tissue under circumstances of so-called health. One important fact,* if confirmed, would tend at once to prove this proposition. In the case in question fowls (which ordinarily resist the inoculation of splenic fever poison) were placed in cold water and thus their vital activity depressed, under these circumstances those which were previously inoculated exhibited the symptoms of splenic fever poisoning. As a crucial test it was found possible by warming to restore the animal to its previous state of health. Before further confirmation, too much must not be drawn from the experiment, but the general law it seems to prove is a reasonable deduction from many other different researches.

But the view of this question to which most attention has been turned is the existence of organisms or their antecedents in the meshes of the tissues of animals supposed to be healthy, and whether the penetration by fungi goes on during favourable circumstances just as we have seen it to occur in all probability under adverse conditions. To decide the point observers† have employed the method of removing and preserving organs and tissues under proper precautions. The results are unanimous in the fact that provided a temperature of about 20° C. be not reached the tissues remain unaltered, but (with some exceptions‡) when incubated under favourable conditions, *e.g.*, absence of disinfectants, &c., organisms appear in a few hours, and that there is a definite order in readiness of appearance of the organisms in the tissues as follows: pancreas, liver, kidney, muscle. Probably the variance of results lies more in the animals employed than on other conditions, since it is conceivable that, in animals kept under as perfect hygienic conditions as possible, the tissues would exhibit few if any fungus forms, and were the method to be applied to the investigation of human tissues, especially muscle, that they would be found free, a result due doubtless to the practice of cooking and cleaning the articles of diet. Where these conditions are not observed we have found discharge putrefying even under antiseptic treatment, and the direct experiment of exciting an osteo-myelitis in an animal constantly fed on putrid material, with the result of causing a septic change in the inflammatory progress§ goes far to establish the above position.

Now that we have seen the possible relations of organisms to the parenchyma of the body and their probable admission per the lymph system, the conditions respecting their existence in the blood-stream are of so peculiar a nature as to warrant a separate study. With exceptions due to race characteristics &c.‖ it may be said that the blood-stream is an extremely unfavourable nidus for any organism, and consequently although we have seen the animal system is everywhere surrounded by these parasites, it is extremely rare to discover them in the blood, a fact borne out by the unanimous results of those who have investigated the question of their existence in the body during "health," and by direct experiment on the properties of fresh living blood.¶ Supposing the latest experiments,¶ which throw great doubt on the conclusion that some organisms flourish in vacuo** to be completely confirmed, the cause of this resistant property of the blood is readily explained if no organism is able to dissociate the oxyhæmoglobic connexion in the state of the health.

At any rate, whatever the explanation be, the importance (especially clinically) of the fact remains unaltered, and may be formulated as the

* 196.

† 132, 4, 43, 118, 186, 196, 263, 82, 170a, 50, 53.

‡ 58, 82, 170a ?

§ 135.

‖ See page 255.

¶ 22, 157.

** 104.

dictum that *during health no vegetable organisms are found in the blood.* While accepting this conclusion we must not lose sight of the active particles which by aggregation compose the Schultze and Osler masses and the nature and connexion of which are as yet indeterminate.

The whole of the foregoing description of the distribution of the micro-organisms is introduced to clear the ground for the subsequent discussion of their occurrence in certain diseases where they appear to possess a causative importance, a question which we may now take up.

II.—Presence of Micro-Organisms in the Septic Diseases known as Pyæmia, Septicæmia, and Sapræmia, Erysipelas, Puerperal Fever, Acute Necrosis, Ulcerative Endocarditis, Infective Myositis.

In attempting to analyse the vast number of observations made on this point, the conditions which decide the value of such researches must be first taken into account before we discuss the relations of each individual disease. In sifting the evidence brought before us we find that four methods have been employed to determine the presence of organisms in the above diseases. These are :—

(1.) Microscopical investigation with or without the aid of reagents, *e.g.*, ether, potash, &c.

(2.) Microscopical investigation, with the aid of staining reagents and methods of clearing sections of tissues.

(3.) Cultivation of original fluids, *e.g.*, pyæmic pus, &c., in suitable media, *e.g.*, Pasteur's fluid, meat infusion, gelatine, &c.

(4.) Inoculation of animals (*a*) by original fluid, and also (*b*) by cultivation fluids, with investigation of organisms found after death in the animals experimented on.

The most trustworthy of these methods obviously are 1, 2, and 4 (*a*). Unfortunately, however, it is only comparatively recently that the Weigert-Koch method of clearing tissues, &c. has been brought into notice, so that observations previous to the last decade, or even later, are of but relative value. Moreover, cultivation offers many loopholes for the accidental introduction of other organisms and poisons, rendering the third method of investigation open to question. (The most approved methods are described at pages 272–3.)

The most complete method, viz., that of observing the exact appearance of the organisms found in the original case, then inoculating some of the fluid into a lower animal, and still finding to all appearances exactly the same organised parasite, coupled with similar symptoms, has been thoroughly carried out by but few experimenters. Where, however, this line has been followed, there is a considerable mass of evidence now collected, showing that the most acute septicæmiæ are accompanied by the development of rod-shaped organisms, while pyæmia, erysipelas, and puerperal fever, the more chronic septicæmiæ are connected with the presence of a coccus form. But the mere fact of constantly finding a vegetable organism in connexion with an acute febrile condition, really carries us but a short distance towards discovering the *cause* of the affection, since they may have arisen locally in consequence of a primary depression of the vital activity of the bodies (*vide sup.*), and it is a well-established fact that the bodies of animals killed by the chemical septic poison, undergo decomposition with extreme rapidity, and in an extraordinarily short time after death are found to be swarming with organisms while none were to be found during life, and very shortly before the fatal termination of the cases.* Under

* 18, 59, 65, 30, &c.

But before leaving this subject notice must be taken of the notion (based on a preconceived theory of the nature of micro-organisms) that it is possible to alter the function of an organism by placing it under strange circumstances,* and this is said to have been done, not only for the so-called schizo-mycetes, but also for the hypho-mycetes. As regards the latter group, it was soon shown† that the inferences drawn from one series of experiments were founded on data of insufficient extent, and that the resistance of the subjects experimented upon was the cause of the vegetable fed fungus not always being a fatal "poison."

But the experiments on the lower fungi‡ attracted more attention and consisted in making numerous successive cultivations of bacillus anthracis in different fluids until the inoculations no longer produced splenic fever; and then the crucial experiment was attempted, viz., that of growing a (supposed) "harmless" form of organism *bacillus subtilis* Cohn, (of hay infusion) in albuminous liquids, such as blood, &c. Obviously such a method is exceedingly untrustworthy, as every change of cultivation soil implies a possible error, and even unsterilised blood was employed to make the hay bacillus savage (verwildern) as the author fancifully expressed it. Moreover, inconstant results were obtained in inoculating these "altered bacilli" and from the description given it would seem that the animals died of the ordinary experimental septicæmia in which bacilli were of course found in the blood and organs.

While we see that no metamorphosis of one kind into another can be considered as at all borne out by the work at present done on the point, it brings us back to the heading of the paragraph with a firmer belief in an actual difference between the kinds of organisms enumerated on page 242–3; and another fact leads us to the same conclusion, viz., the inability of two organisms to flourish equally well in the same fluid, and again the results of inoculations practised on potatoes (boiled) as a cultivation soil. In the latter case each organism is strictly confined to its own territory, and does not mix with its neighbours, showing that the vital phenomena are different in each kind. The question, therefore, of difference of function is at present a matter of inference, and awaits further investigation.

In concluding this sketch of the unsatisfactory state of this question, reference must be made to the mode of entry of the septic poison in the above-mentioned diseases. Apart from the obvious loop-holes in the shape of wounds on the exterior of the body, there remains the possible absorption of poison by "healthy" mucous membranes, and further, the mode of conveyance of contagium. As far as the chemical septic poison goes, we know it can be absorbed by healthy mucous membranes, but the penetration by parasites is referred to on p. 245, and requires further research. The mode of conveyance is most commonly the hands and integuments, and more rarely the atmosphere, of which many positive instances are recorded. Flies have been shown to convey the poison of acute experimental septicæmia.§

III.—Life History of "Septic Bacteria."

(*a.*) *Structure.*

The structural plan of all the organisms enumerated on pages 242–3 is simple, consisting merely of a protoplasmic body with a cellulose envelope or skin.

---

* 42, 97.
† 94, 159.
‡ 42.
§ 65.

Protoplasmic Body.—The protoplasm forming the central mass presents the ordinary finely granular or ground glass appearance of elementary protoplasm, and in some kinds show numerous highly refracting granules and droplets of a fatty nature.

The protoplasm is readily stained with the aniline dyes, and in some kinds (coccus form) is stained by other vegetable dyes, *e.g.*, logwood, &c.

Cellulose Envelope.—This is seen in unstained specimens as a sharp, well-defined dark line, surrounding the organism, and so giving the latter the appearance of having a double contour. This sharp outline is most characteristic, and serves as a means of instant detection of organisms when mixed among structures similar in appearance. It stains readily with iodine, and turns blue on the addition of diluted sulphuric acid. Further, it is insoluble in alkalies and acids unless of considerable concentration, and also is insoluble in alcohol and ether.

The protoplasm has been the subject of chemical analysis,* the main results of which, though necessarily imperfect, are as follows: The organisms were precipitated by adding hydrochloric acid up to 3 per cent., and boiling for a few minutes, when they fell as a white flocculent precipitate. The mass of organisms was then collected, washed, and extracted with alcohol and ether.

Fat.—From the latter a fatty compound was obtained to the amount of about 6 per cent. of whole mass. Its percentage composition gave 72 per cent. C. and 11·73 per cent. H.

Albumin.—An albumin termed mycoprotein was obtained by the prolonged action of caustic potash on the mass. Mycoprotein is soluble in the alkaline fluid and precipitated from that solution by hydrochloric acid and falling as a white amorphous flocculent precipitate. The estimated proportions were C. 52, H. 7, N. 14, *no sulphur*. The original mass of organisms contained about 50 per cent. of mycoprotein.

Mycoprotein as an acid albumin† has been further investigated; "9 grammes of it gave 8·7 grammes ash free substance" (Schaffer). Heated with KHO, there were developed ammonias and amylamin, while the cooled residue when distilled with dilute H_2SO_4 gave skatol, hydrocyanic acid, and hydric nitrite. Afterwards indol appeared after ætherisation, and later phenol to the extent of 15 per cent. of the weight of unaltered mycoprotein, and valerianic acid to the extent of 38 per cent. From the potash residue leucine was obtained.

The cell membrane is of course insoluble in dilute alkali, and like that covering the yeast cell, contains nitrogen.

So far as has been determined, the zoogloea substance is an albuminoid.

Additional points in their structure are the following:

1. The coccus elements, which are collected in the form of a chain, are kept in this arrangement in spite of currents in the fluid in which they are immersed. Although deep staining only sometimes shows a slightly coloured substance, there can be no doubt of the existence of a ground substance uniting them, a ground substance of the same nature as that uniting individual forms into zoogloea masses, *vide infr.*

2. The further investigation of the active movements of some organisms when in a good medium resulted in the description of a cilium or flagellum attached to some rod and spiral forms in the same longitudinal axis. This cilium was about of equal length to the rest of the rods.

3. Pigment.‡—Both coccus and bacterium forms may be pigmented, and the colours that have as yet been described are red, yellow, orange,

---

* 186, 182.
† 239.
‡ 244.

green, blue, violet, brown, peach colour. Of these the first two are insoluble in water. As regards the first three, it is probable that the second and third are varieties of the first, since all the colours, like other vegetable dyes, show considerable alteration according to the reaction of the fluid in which they are contained. Thus red remains of a carmine tint in acid solutions, but changes to yellow on the addition of ammonia. As regards their solubility they may be classified as follows: (1.) Soluble in water: red (very slightly), yellow, green, blue, violet, brown, peach colour. (2.) Insoluble in water: *red* for the most part.

Of special reactions are to be noted the change of blue to red by acids (cf. litmus), and to violet by ammonia.*

The spectroscopic examination† of the pigments requires to be further extended.

(*b.*) *Modes of Development and Reproduction.*

Either by fission or by spores. As far as is yet known, the coccus forms multiply by fission only, but some kinds of bacillus reproduce themselves by longitudinal extension into filaments, in the interior of which spores subsequently develope.

1. *Fission.*—The *rod* forms split transversely to their long axis, the protoplasm dividing, and then around each new extremity thus formed the cellulose envelope is continued. The two new elements thus formed, however, are often united (just as the coccus forms may be), by an invisible ground substance, so as to form chains of two or many more rods.

The fission of the *coccus* forms presents at least this difference, that the division may take place in any direction, but usually continues in the same line, so as to form the chain above mentioned. Sometimes, however, the splitting proceeds in two directions, and thus groups of four (sarcina form), or even more have been described.

The *Time* which organisms are said to occupy in the course of division has been differently stated by authors who have continuously observed different forms, the estimates varying from 10 minutes to half an hour, varying no doubt with the temperatures, &c. A single rod, therefore, has been computed to produce 16,377,230 of its kind in 24 hours.

2. *Reproduction by Spores.*—The existence of spores was surmised‡ before the actual demonstration of them. So far as our present information goes this method of multiplication is confined to some rod forms (bacilli) and takes place as follows: The rod grows longitudinally into a long wavy filament (leptothrix form, fig. 7), and, as growth proceeds, small oval aggregations of protoplasm are observed forming at intervals in its interior. Continuous investigation shows that these particles or spores as we should now call them become free and undergo a further cycle of changes. But spores (brilliant points) have also been observed in rods also which have not elongated into filaments. Under these circumstances the rod is observed to be broader than in the free non-spore-bearing condition.§ At present it seems that one spore corresponds to one adult rod, both in its virgin and subsequent development, thus differing from some algæ in which two spores are found in one cell. Thus the spore consisting of an oval mass of protoplasm surrounded by cellulose (which exhibits powerful resistance to the action of heat reagents, &c.) when placed under favourable circumstances commences to grow at one end, and by continuous increment lengthens out into an adult rod of the average length and breadth. The intermediate

---

* 79*b*.
† 244–45.
‡ 57.
§ 131.

stages of this process probably gave rise to their being described as peculiar bacteria, helobacteria, kopfbakterien, &c., and are illustrated in fig. 8.

3. *Zoogloea.*—By continued multiplication most of the organisms in the foregoing description form agglomerated masses termed Zoogloeæ, which consist merely of numerous adult forms united by an albuminous ground substance. *See* Fig. 2.

(*c.*) ***Adult life***, including (1) chemical changes; (2) physical changes.

(1.) ***Chemical changes.*** (*α*) gaseous; (*β*) solid.

(*α*) The lowest organisms have gas interchanges similar to those of the mycetes next above them, that is, ***they require and absorb oxygen*** and ***give out*** carbonic acid.* A beautiful experiment showing the truth of this law was accidentally made as follows:† Bacteria were accidentally observed in a solution also containing the chlorophyll-holding infusorian the euglena viridis. On exposing the preparation to the light, the bacteria were observed in active movement, &c. in the neighbourhood of each infusorian, while in the empty spaces of the microscope field, where of course the proportion of oxygen was much less, there they were less active, and by darkening the field were brought to rest.

A few years back it was considered as certain‡ that these organisms might physiologically be divided into two great classes, the aerobian and anaerobian, those which flourish in the presence of free oxygen and those to which that gas (when free) is an obstacle in the way of their development. Later researches§ (referred to above) throw doubt on this conclusion, and tend to preserve the universal truth of the principle (allowed for the majority of forms) that for their active growth the presence of free oxygen is necessary. The immense importance of this point renders it most desirable that a definite conclusion should be attained since it lies at the foundation of an accurate explanation of the mycotic process, see page 245. Whatever unfortunate doubt still exists as regards the universal application of the law above stated, at least it is well established that oxygen is necessary for the maintenance of the putrefactive fermentations, in which variety of the septic changes we are most interested.

Considerable attention was attracted at one time by experiments‖ attempting to show that compressed oxygen had a powerful effect in checking the development of these organisms and even abolishing the poisonous property of anthrax fluids (blood, &c.). It is perfectly comprehensible that very great excess of any reagent would have a deterrent effect on the lower fungi, but the experiments referred to were based on an incomplete knowledge of their development—more especially of the bacillus anthracis—and have since been shown¶ to be of no value.

But little is known of their behaviour towards other gases, but a fairly complete study has been made of their growth under different kinds.** Thus in all cases oxygen, whether present as such or in air, whether burnt or impure, favoured their development, which on the other hand was prevented when the necessary cultivative material (muscle) was kept in an atmosphere of either nitrogen, hydrogen, carbonic oxide, carbonic acid, nitric oxide, or coal gas. While the introduction of oxygen was always followed by a rapid growth of organisms. The same point is illustrated in the ammoniacal decom-

---

* 157.
† 79*a*, 129.
‡ 196.
§ 104, 195.
‖ 20, 196.
¶ 87, 134, 196.
** 195.

position of the blood which has been shown to be impossible in the absence of oxygen.*

(β.) This subject is treated of under the head of "Structure."

(2) *Physical changes.* (α) heat; (β) light; (γ) electricity.

(α) *Heat.*—Of all forms of energy produced by or necessary to the life of these organisms heat is the most important, and the first question on which so much has been based is this:—"Within what ranges "of temperature can these organisms live, and what temperature is "most favourable to their active development and multiplication?" Beginning then with the lowest temperatures, the answer seems to be that no degree of cold attainable by present means can exert a fatal influence on these fungi, since the bacillus anthracis has been subjected by means of solid CO_2 and ether to a temperature of −140° C.† without any influence on its vital properties.

The next point, what is the (moderate) temperature at which the organism flourishes best, is found to vary with the kind of organism. Experiments of this kind are necessarily rough, but a considerable difference has been shown to exist with regard to different "tribes." Thus the coccus and bacterium forms diminish in activity as soon as their surrounding temperature rises above 40° C., while the bacillus subtilis will flourish most actively at 43° C. to 45° C.‡

As regards the low point of favourable temperatures, most of the organisms become stationary at about 10° C. (but the multiplication does not probably actually cease till 5° C. (bacterium termo 5·5° C.§) and again the bacillus forms are the first to show activity, the bacillus anthracis thriving fairly enough at 20° C.

But now we enter upon the most difficult point of all, viz., the death point of the adult forms. With our present information this problem is still unsolved, since continuous observations of each kind of organism and its spore form, when subject to gradual elevation of temperature, are wanting. Both adult and spore forms differ as to their death point according to the media in which they are contained. That is, if they are in watery solutions, they all enter into heat rigor below 110° C.‖ While dried they may sustain a temperature up to 135° C. These high points refer solely to the spores of bacilli and more especially bacillus subtilis, it being impossible in the absence of data to give a table of every form. But the (lower) coccus and bacterium forms perish at lower degrees of heat; thus, bacteria termo is killed by prolonged heating (14 hours) at a temperature of 45° C. in a watery solution.

In generalising these—

Adult coccus and bacterium forms are killed at about 45° C.
" " bacilli " " " 50° C.
Spores - - - " " " 140° C. when dry.

As soon as each organism can be definitely recognised a temperature range should be worked out for every form, and thus the question of abiogenesis approached with some surer basis.

(β) *Light.*—The influence of light on the growth of these organisms is, if anything, unfavourable, one series of experiments¶ showing this apparently conclusively, and while it cannot be shown to exert a very powerful effect, still it is quite unnecessary to their growth which proceeds perfectly well in the dark.

---

* 83.
† 27.
‡ 57.
§ 78.
‖ 196.
¶ 62*a*.

(γ) *Electricity*.—The little attention that has been drawn to this point has resulted only in showing that the supposed* inhibitory effects of the battery current on the active growth of organisms is due to the electrolytic destruction of the nutrient fluid containing them; in which a strongly acid reaction developed around the positive pole, with death of the organism in its neighbourhood, while the negative pole was surrounded by alkaline fluid, in which the activity of the organisms was much abrogated, but not entirely† abolished. The same fact was exemplified by employing potatoes as the cultivative soil.†

Magnetism has not yet been investigated in relation to this branch of organic life.

(*d*) *Habitat*, under (α) Normal and (β) Abnormal Conditions.

α. This question has necessarily been pretty completely described in the introduction, but some supplementary remarks may be of value, especially with reference to the animal system, some details with regard to which could not be discussed under general principles. As regards the world external to the system, the "universal" distribution of organisms was referred to, and now, by the term normal condition, we mean that where rest, warmth (30°—40° C.), and nutrient pabula exist, there organisms will develope, provided there is free exposure to the air; the importance of rest is shown by the fact that motion prevents the development of organisms.‡ With reference now to the animal system, and we need only refer to the higher mammals, the statement was made that a general distribution of vegetable organisms throughout the body signified constitutional disturbance. Against this may be adduced the fact of organisms ("sarcinoid") being found in human blood of persons apparently in health,§ and much higher organisms frequently present in the blood of mammals, such as the rats, while seemingly robust (the rats are all foul feeders). Supposing the subjects of observation to be in good health (to all appearances), the condition of constitutional disturbance in cases of simple mechanical mycosis depends on the mass of organism infesting the system. The organisms described have not been shown to possess any specific property, and at the same time they are but few in number. With reference further to the "sarcinoid" organism described in the blood, it should be understood that the method employed was that of direct observation and cultivation, and next that the fine bright particles frequently observed in the blood, and probably derived from the "molecular basis" of the chyle have often been seen in groups of two, three, four, and five, giving the appearance of sarcinoid cocci. Under these circumstances, and considering the vast number of observations which have been made on the blood of "healthy" people, the truth of the law expressed on p. 247 must be held as unshaken.

β. As regards abnormal conditions, *see* pages 257, et seq.

(*e*.) *Influence or Action on Tissue Elements, dead or living.*

The active influence of organisms on different substances is, so far as we know, simply that of destruction and assimilation by the organism of those products capable of affording it the elements necessary for its growth and multiplication. As will be seen, the compounds which they are able thus to split up are of comparatively weak chemical affinity, so that their resolution into their constituent elements can be effected with-

---

* 240, 101.
† 57.
‡ 119, 216.
§ 57, 87*a*, 21, 184, 48, 153, 162.

out great display of energy by the katalytic substance. Thus the question of their influence on different compounds resolves itself into the simpler question of their food-supply. Before tabulating these lower compounds, reference should be made to the higher; these had best be considered under each of the classes of the complicated substances.

(1.) *Dead Tissues*, including—

(α) Inorganic substances.

(β) Organic „ { α. Fats. β. Albuminoids. γ. Carbohydrates.

NOTE.—Only those substances in relation to which they are most commonly found are mentioned.

(α) *Inorganic Substances.*

Of inorganic substances we know that they require H, N, O, for the composition of their protoplasm and cellulose.

Reaction of Fluid.—It is in the course of their metabolism that a change is effected in the reaction of the fluid in which they are contained. Thus an acid fluid becomes alkaline. Further, it is found that acid liquids are on the whole unfavourable to the growth of organisms, and alkaline ones favourable to the same. Organisms are said to be able to accommodate themselves to the reaction of the fluid into which they are plunged;* and perhaps this is true within narrow limits.

Although many of the substances are described below as being split up, &c., it is not intended to be understood that the organisms have been PROVED to be the causative agents of this katalysis, but that such decomposition is an accompaniment of their life.—*Vide* Resumé, p. 269.

Ammonias are split up, and the nitrogen employed in building up the protoplasm; "bacteria," are also said to be the causes of nitrification.† In the residue of Cohn's fluid after growth in it of organisms there is found the ordinary triple phosphate.

Nitrates are converted into nitrites during growth of organisms.‡

Sulphates.—Beyond being found in close connexion with phosphorus in albuminoid liquids, the part these play is unknown. It was once thought a sulphate of phosphorus was formed with poisonous properties.

Phosphates have for some time been noticed to be present in quantity where substances are undergoing active decomposition, but attention has been more attracted in this direction lately, and the phosphorus given a more important *rôle* in the katalytic process.§ In ordinary substances the phosphorus is present as phosphate. The importance of this as regards the growth of organisms is shown by the simple experiment of using urea solution as a cultivating fluid. Used pure without phosphate, urea is extremely unfavourable, but on the addition of a small quantity of phosphate (lime) is rapidly split up, *vide infra*. In any case the earthy phosphates, and especially phosphate of lime, seem to be almost indispensable to the septic decomposition of albuminoids. No phosphites, nor hypo-phosphites, are found, so that the action of phosphorus salts, though obviously important, is not easily explicable.

(β) *Organic Substances.*

(α) *Fats.*—The ordinary fats become rancid, *i.e.*, fatty acids are developed by the splitting of the original compound. But most

---

* 187.
† 241.
‡ 154.
§ 148.

attention has been directed to the supposed action of organisms on the fatty butyric acid especially as a butyrate. Coupled with the katalytic destruction of this substance is the presence of a bacillus, which has been therefore stated to be the necessary ferment.* The products of decomposition are variable, including hydrogen and carbonic acid.

(β) *Albuminoids.*—The actual influence of organisms on dead albuminoid substances, just as in the other chemical questions of their life, rests on coincidence rather than absolute proof. Such coincidence goes to show that albumin splits into glycocoll, gases H_2O, CO_2, leucin, tyrosin, fatty acids, butyric and acetic, indol, skatol, phenol, creasote, phenyl-propionate, and acetate, and of these that leucin again under the same circumstances (*e.g.*, fluid swarming with bacterium termo) divides into ammonia and oxycapronic acid, and glycocoll into ammonia and hydro-carbonic acid. Thus we see that the destruction of albumin in the process of fermentation (septic change) is exactly similar to that effected by hydrate of potash.

The destruction of albuminoids after death† must here be considered as in relation with their possible change by "organized ferments." From three to five hours post-mortem, volatile fatty acids ranging from capronic to acetic appear. Lactic acid, to which the acid reaction of dead tissues is due, is derived from the glycogen present. As further decomposition occurs the lactic acid disappears, and in its place is found succinic, while this again is masked by the alkalinity of the tissue ensuing as a result of the development of ammonias.

(γ) *Carbohydrates.*—The metamorphosis and destruction of carbohydrates is probably an hydration process, since it can be imitated by the simple action of superheated steam. But the simplicity of this chemical operation renders it only necessary to refer here to the metamorphosis of lactose into lactic acid. In this particular case there is always present one form of organism (bacterium lactis‡) which has been considered to commence the process, if not to carry it on.

A wider discussion of the process of decomposition in the substances enumerated is to be found in the ordinary text-books and papers referred to, but cannot be entered into here, as fermentation is not absolutely proved to be the direct result of the organism's life.

2. *Action on Living Tissues*, including (*a.*) *Modes of Growth in*, (*b.*) *Changes produced in.*

(*a.*) *Modes of growth* of organisms in tissues are obviously regulated by the lines of least resistance. The easiest method of observing this phenomenon in the connective-tissues is that of inoculating different kinds of organisms on the cornea, the transparency of which admits of the growth being watched for a considerable time. As may be readily conceived, they spread along the lymph (cell) spaces, giving rise to disorganization of the corneal structure, and in the case of micrococci showing as yellow-brown opaque projections§ at the border of the ulcerated surface. Many forms have been thus experimented with and similar results obtained, but most frequently micrococci, of which that found in diphtheritic membranes, the so-called micrococcus diptericus, is accompanied by a fibrinous membrane covering the surface of the corneal ulcer‖ or mucous membrane if planted there. The same mode of growth is observed in cases of local infective inflammations, such as ordinary erysipelas, where along the spreading edge micrococci

---

* 196.
† 79.
‡ 157.
§ 69, 92, 146, 76, 193, 259*a*.
‖ 76, 151.

are seen invading the lymphatics and lymph spaces of the connective-tissues.* This coincidence does not, however, prove that they act as the cause of the hyperæmia swelling and pain at the spreading border; a question discussed below. Further, in injections of organisms into the peritoneal cavity, they rapidly find their way into the lymph vessels of the diaphragm and other lymphatics, so passing into the lymphatic duct from which they gain access to the venous circulation. This route has been proved experimentally by the simple expedient of placing a temporary ligature on the duct just as it joins the subclavian vein, and observing that until the moment of release of the ligature no organism was to be found in the blood-stream.

Thus far their growth in connective-tissue has been thoroughly studied. The behaviour of organisms in the blood vessels has been also studied both during and after life; in the former case they are found in the periphery of the blood stream where the current is more sluggish, and frequently are seen adhering† to the walls of the vessels, sometimes at the bifurcation of arterioles and capillary junctions temporarily obstructing the stream. Although seen as in pairs or chains (if cocci) in the blood vessels, it is more than probable that they do not form zooglæa masses during life,‡ and thus their supposed action in bringing about embolism is a matter of doubt. It cannot, however, be denied that in some particular kinds, *e.g.*, bacillus anthracis, that in the large quantity of organisms relatively to the calibre of the vessel (see fig. 15) we have an important interference with nutrition if only from the view of a mechanical mycosis; thus this condition is to be compared with the mycotic process of the hyphomycetes, and as yet has only been indubitably shown to occur with rod forms of the lower fungi.

The time occupied in spreading through the blood channels is of course exceedingly short compared to that occupied in traversing the lymph spaces, the difference being produced by the powerful agency of the swifter current. Reference may here be made to the existence of organisms in the white corpuscles, a fact more frequently observed than understood, since, except in those instances where the corpuscles may be observed to be crammed with organisms (fig. 16), the intra-corpuscular existence of an organism has been held both to show the paralysed condition of the corpuscle and its easy mycosis, and, on the other hand, to indicate the power white corpuscles have of absorbing foreign bodies and thus acting as carriers of the virus from one point to another. Possibly a white corpuscle may perform its wandering functions provided only one or two organisms are in it, so that both ideas may be true. Coccus forms as well as rod forms have been observed in white corpuscles.§

The growth of organisms in the various organs is found to be different, a condition probably due to the difference of structure only, offering a mechanical resistance to the escape of organisms from various regions. Thus the favourite position for organisms, viz., the meshes of the spleen, the malpighian glomeruli in the kidney, &c., &c., are all spots where entry is easier than exit, and as is seen in the aspergillus mycosis, &c., it is in these latter traps, as it were, that the organisms are arrested and commence their virulent growth, from which it is probable that on the first introduction of organisms they are hurried into the capillaries where if the resisting power of the animal be insufficient they rest and grow into the larger vessels. This conception of their primary

---

* 164, 77, 193, 215*a*.
†22, 47.
‡ 259*a*.
§ 99, 104, 217, 25.

lodgment and secondary growth and rapid diffusion throughout the body is borne out by all we know concerning the phenomena of multiplication of these organisms, one of the most important conditions being rest, since it has been shown that motion prevents their development.* Probably this explains why in some acute septicæmiæ organisms are found in the comparatively stagnant fluid of the serous membranes, peritoneum, &c., while they are apparently absent from the blood.†

The rapidity with which the tissues become extensively mycosed differs both with the kind of organism and the tissue which is invaded. Thus in the corneal disorganization it is a matter of days, in malignant œdema and traumatic gangrene it is a question of hours, so that no rule can be laid down to indicate the time, since one organism will differ in its rate of progress according to the structure it is invading, but we may make the broad generalisation (from the small number of observations at our disposal), that the rod forms spread more quickly than the coccus-forms.

While on this topic the expression‡ that there is a constant struggle (under normal conditions) between the protoplasm of the animal body and that of the lower fungi constantly brought to it in the food, brings under notice another condition which regulates the growth of organisms in the tissues, and that is the varying resistance to such growth by the animal according to the state of nutrition in which its protoplasm happens to be.

Again, organisms differ exceedingly as to their penetration of the blood vessels or not; thus in inoculations of a double character§ on wounded surfaces, *e.g.*, the ear, it is found that micrococci, while exerting a powerful topical action on the tissues, have little or no tendency to enter the blood-stream, while bacilli in a similar situation rapidly do so and become diffused throughout the body.

Thus far we have considered the growth of organisms in tissues the nutrition of which is supposed to be fairly normal, but there remains to be mentioned the growth of organisms in tissues in which by previous exposure to foreign agencies the parasitic fungus has to deal with different circumstances. This subject has been studied with reference to the connective-tissues, as in shot wounds, walls of abscesses, &c.‖ The organisms (micrococci) are found in the lymph spaces of the tissue, having grown in from the surface of the granulations. In this way they come to invade the walls of the blood vessels and the meshes of ligatures. By such invasion the vessel walls are weakened, nay, actually destroyed,¶ and hæmorrhage results, a not infrequent clinical observation in septic wounds. The same practical point of course is to be considered in the case of catgut ligatures. The colonies of micrococci in the oldest recesses of the wound show the changes observed in artificial cultivation, viz., the aggregation into large masses and fusion into one yellowish-brown conglomeration.**

Reference to the time occupied by different poisons in penetrating the surface of a wound is best made here, and the information is unfortunately limited in amount. The researches†† are quite recent, but only give the time during which it is possible for enough poison to penetrate in order that the symptoms may be obtained. It was found that the poison of splenic fever took more than an hour to penetrate a raw surface,

---

* 216, 119.
† 187.
‡ 81.
§ 134.
‖ 31, 191, 132, 123, 134.
¶ 132.
** 132, 151.
†† 65.

while sheep-pox infected in a few minutes. This interesting point requires further attention.

(*b.*) The problem of the growth of organisms in tissues is fairly easy, since it can be put to experimental proof without much difficulty, but the question as to the changes wrought *by* them is another thing altogether. Since in this second case we are dealing with cause and effect, the post hoc, &c. fallacy renders the few direct observations open to considerable doubt. Attempts have been made to explain or hypothecate the action of an organism in bringing about its supposed effects, and the experiments that are directed to this point consist in observing startling coincidences. Accepting a few instances in which the difference between the usual order of things, and that consequent on the introduction of organisms was the method employed, the whole question, even then, would be discussed on insufficient data, provided reference was only to be made to a "clean" organism. But since practically it makes little difference whether the tissue changes are brought about by the organism itself or some agent that it "carries on its back, as it were,"* we may study the changes in the tissues on this basis; it being clearly understood that the effects described cannot be said (as yet) to be produced by the agency of an organism only. It will not be out of place here again to draw attention to the extremely small quantity of some unorganised ferments required to produce wide effects, and therefore, although we may appear to be introducing only an organism (*e.g.*, cultivated bacillus anthracis), the possible introduction of an alkaloidal substance is to be kept in view.

We shall consider, then, the changes brought about in the different tissues by the introduction of organisms both in cultivation fluids and original maceration fluids. In all cases the blood seems most profoundly altered, while the other tissues exhibit rather secondary effects, viz., inflammation, œdema, &c. To consider them categorically:

Blood.—This is noticed post-mortem as being fluid (not coagulated)† tarry, and of a dark black-brown colour. The blood pigment being partly held in solution in the laky condition of the blood just mentioned, it tends to stain all tissues it comes in contact with, *e.g.*, endocardium, and the lining membrane of the larger vessels, and in guinea-pigs the subjects of experimental septicæmia the well-known crystals of hæmoglobin have been recognised as already formed.‡

Red Corpuscles.—In the minuter changes most attention has been drawn to the crenate and altered condition of the red corpuscles, but beyond this being an exaggeration of what occurs in every preparation of blood, there is nothing special in the condition, and certainly is not the general ill effect of the growth of an organism.

But a noteworthy feature in splenic fever and also in cases of experimental septicæmia is the rapid collection of the blood corpuscles into "islands"§ as against the formation of rouleaux.

An advance of both these conditions has been noted in rabbits poisoned with putrid blood (probably a rod-shaped organism mycosis) in which the red corpuscles were totally broken up, only detritus remaining‖

White Corpuscles.—Leucocytosis¶ has been frequently observed in septic diseases, but this may depend, too, upon the coexistence of suppuration. The penetration of white corpuscles by micro-organisms is referred to on p. 15.

---

* 18, 43.
† 274.
‡ 115.
§ 254, &c.
‖ 251, 274.
¶ 109, 141.

Gases.—In experimental septicæmia the percentage of oxygen is diminished to 19 in arterial blood, and a rather less diminution in the venous blood; while in the latter the carbonic acid is considerably increased.*

Infectivity.—It is necessary here to remark on the extreme infectivity of septicæmic blood, *i.e.*, in experimental septicæmia. It has been frequently shown, first in a brilliant series of experiments† that $\frac{1}{1,000,000}$th of a drop of blood was sufficient to cause death with certainty in 24—48 hours. (The animals employed were rabbits, and even one billionth of a drop was often effective.) This requires no further comment save that the blood in these cases always contains organisms. Cf. the lactic fermentation.‡

Thus on the whole the appearance of the blood under the circumstances of splenic fever and other septic poisons would favour the theory of a deoxydation and consequent asphyxia brought about by the growth of the organism: one variety of a biological mycosis. But the therapeutical application of this theory has not been successful as yet in the administration of oxygen to the poisoned animal.§

The connective-tissues and internal organs undergo one or other of two processes, viz., the simple necrotic process and ordinary inflammation, and more especially œdema‖ and gangrene. To commence with the latter, the inflammation which soon appears around the inoculated spot, rapidly spreads around the abdomen, making itself obvious by considerable swelling. Usually the animal dies before this condition has time to make itself general. On cutting into the œdematous subcutaneous connective-tissue it is found to be of a pale yellow gelatinous appearance from the distension of the meshes with serous fluid, which is sometimes pink and bloody.¶ This is the result obtained in experimenting with several of the bacilli, *e.g.*, bacilli of malignant œdema and bacillus anthracis. Besides fluid, gas often developes in the connective-tissue, and is found to be carbonic acid.** But again, commencing with the inflammatory blush, this may extend but a short distance and so form patches, the centre of which dies partly from the violence of the process and partly from the pressure exerted on the neighbouring blood vessels by the œdema fluid. Thus is formed a "malignant" pustule which may be summed up as a combined inflammatory and necrobiotic process. In spreading traumatic gangrene this same process is carried out on a broader plan, the inflammatory blush, &c. spreading rapidly in all directions and followed by the death of the tissues.

Experimentally the necrobiotic process consequent on the inoculation of micrococci has been more fully worked out in *gangrene* of the rabbit's ear†† consequent on the growth of these organisms through the tissues and showing in the sections as filling the blood vessels. Tissues, the seat of necrobiosis, present the ordinary gangrenous appearance, are cold, dusky, with blebs appearing sometimes on the surface; but when this occurs as the breaking-down centre of an inflammatory focus, a dirty serum exudes from the centre. The changes around an infarct in a septic case, which are usually termed suppurative, are rather necrobiotic, and fatty degeneration is an extremely marked feature in the tissues in this condition.‡‡

---

* 60.
† 68.
‡ 157.
§ 265.
‖ 274, 288, 333, 193, 3a, 286, 7.
¶ 274.
** 30.
†† 134.
‡‡ 87.

Reference has been made above to the raised inflammatory edge of the erysipelatous blush, and this point may now be further explained as throwing light possibly on the action of organisms. It was stated on p. 257 that micrococci had been found more especially in the advancing border, and it has been found that serous fluid taken from this part and containing cocci, when inoculated into the skin of lower animals, produced the same series of changes as seen in man, and the organisms, if cultivated and reinjected, again produced the same results.

Note.—It will be observed that by this method, albuminous fluids, the seat of active change, were injected as well as the organisms.

It is comparatively easy to explain necrobiosis as a result of local mycosis, since by invading the walls of the vessels and producing thrombosis, tissue death inevitably results. And, besides, death may occur from mechanical compression of the vessels from the œdema fluid poured out beneath the semi-elastic skin, since the rapidity of the exudation is so great that the lymphatics cannot carry it off, and are in their turn similarly compressed.

But as to the production of the phenomena of inflammation by organisms no theoretical explanation can be considered satisfactory, but what direct evidence there is may now be examined.

The mode of experimentation* has been that of observing the mesentery or some convenient point of the circulation under circumstances admitting either of the study being conducted in pure air or in addition when the membrane observed is exposed to the impact and action of micro-organisms and more especially micrococci. The same objection applies to these experiments as to those in which micro-organisms are introduced within the body, viz., that more than organisms are applied to the surface investigated. But there are general deductions obtained from clinical observation confirming the general law that micro-organisms act as irritants to naked tissues, and therefore keep up an inflammatory process wherever they lodge, and thus, if not necessarily of causative importance in such diseases as diphtheria, no doubt by their presence possess a secondary influence in fanning the inflammatory mischief.

The changes in the larger glandular organs observed in connexion with (supposed) saprophytic diseases are briefly those of cloudy swelling,† and the change is most marked in the spleen, then the liver, and the kidney; the protoplasm of the corpuscles becomes finely granular, and provided the affection be of sufficient duration, fatty degeneration completes its destruction. The fatty degeneration coupled with necrobiosis is described above. The liver in experimental septicæmia still performs its glycogenic function.‡

The spleen is invariably swollen, sometimes of a pink-grey colour and often of a dark maroon tint, which is always extremely soft, and if the autopsy is delayed it rapidly becomes diffluent. This condition of spleen is of course not solely the accompaniment of septicæmia.§

Mention may here be made of the hæmorrhages so constantly found throughout the body in cases of septicæmia, whether its origin be the supposed mycosis or the chemical poison.

IV.—Septic Intoxication.

Although in the introduction to this Report sapræmia was placed first in the list of kinds of blood-poisoning or septicæmia, it has been found more convenient to defer its study until more general information on the

---

* 288.
† 204.
‡ 274.
§ 255.

phenomena attendant on the life of the "septic bacteria" had been collected. Moreover, its importance is dependent on the decision that we should come to as to the part played by organisms in the septic process. But this question was discussed fully on page 249, therefore need not be reopened here, and all we have to deal with as regards sapræmia is to discuss the nature of the poison and its leading characteristics, taking it as developed from albuminous substances by means of the septic or katalytic process.

Included in the following description are the cadaveric "alkaloids" of such forensic importance, and which have been entitled ptomaines.

As a better preface to the consideration of the chemical septic poisons (as understood at present), a brief sketch of the researches which have brought us to the present aspect of the question is here interpolated.

The earlier writers,* recognizing fully the connexion between the symptoms of blood-poisoning and the process of putrefaction, took animal tissues, caused them to putrefy, and analysed the results as for a chemical poison, inasmuch as the idea of a saprophysis had not then sprung up. We may now glance at the products of decomposition of animal albumen as they found them, and see how far each of them may be considered as poisonous.†

Ammonias act as cardiac poisons.

Ammonium sulphide produces, when injected in sufficient quantity, collapse, diarrhœa, death.† Small doses cause a general rise of temperature.

Fatty acids:

Formic, Acetic, Butyric, Valerianic, &c. — All cause death when introduced in quantity, without, however, septicæmic symptoms.

Leucin, Tyrosin — Both cause pyrexia, even when injected subcutaneously. See Pl. III.

Thus of all the products of decomposed albumen, none of the commonest can be for a moment considered as the cause of the symptoms of septicæmia. But to resume the sketch of the observations on this point, we find that, within the last 20 years, researches referred to at p. 269, show the existence of bodies in small quantity resulting from the destruction of albumen, and, while giving the reactions of alkaloids, produce also the symptoms of blood-poisoning. The following description, then, of the chemical poison refers to this later known product, and the above reagents are left out of consideration, in most of the researches the poison being separated from them.

The resistance of animals to the chemical sepsin is found to vary just as we see (p. 255), resistance to the so-called parasitic fungi is different; and moreover, has often not the same amount of action in the same animal.‡ This variation is doubtless due to the rapidity with which the animal can excrete it, according to its state of health.

The means of entry of the septic poison is usually the blood stream, either directly by wound of vessel or indirectly through connective-tissue. Its absorption by lymphatics is necessarily slower, and further, experiments have been made,§ showing that sepsin, when sprayed in the atmosphere, and even injected into the trachea,‖ did not produce septic symptoms in animals exposed to it; while absorption by the alimentary canal always gave rise to the usual phenomena of acute sapræmia.¶

---

* 93, 166, 33, 249.
† 277.
‡ 18.
§ 162, 248.
‖ 60.
¶ 30, 112.

We may best begin, therefore, with the nature of the poison.

(*a.*) *Nature of poison* { (1.) Mechanical properties. (2.) Physical ,, (3.) Chemical ,,

(1.) *Mechanical Properties.*—The poison has been variously described as particulate, and not, diffusible and indiffusible, crystallizable and non-crystallizable, but all statements concur as to its chemical properties. It remains, then, briefly to discuss the apparent inconsistencies of the results bearing on the mechanical properties of the poison. Differences in results may naturally be looked for where observers have commenced with any substance that seemed best. More facts would have been discovered on this point had one substance (muscle or whatnot) been employed throughout, since in every case an extremely complex body was chosen with, of course, numerous possible derivatives. Then again, many observers, especially of the French school, do not discriminate between the chemical poison and the supposed organised fungus, treating the putrid mixture as simply containing "septic poison." The point now being considered in this part of the subject is the chemical sepsin, and we may say (on reviewing the mass of tangled evidence), that its mechanical properties depend on its mode of preparation, and that the sepsin obtained from putrid fluid by precipitation by alcohol and subsequent extraction with distilled water* ought not be compared with the sulphate of sepsin† obtained by the Stas-Otto process or modifications of it. In the former case it is conceivable that the alkaloidal sepsin is carried down by and is in intimate connexion with the fine particles of albumen precipitated by the alcohol so that the well-known sterilisation of the fluid by passing it through porcelain,‡ &c. is accounted for, while in the latter case when purified and crystallised it is found to be diffusible and not particulate.§

The earliest work on sepsin showed that it was a fixed non-volatile substance.‖

As regards its ordinary physical condition it has been obtained as crystals¶ and as a fluid.**

(2.) *Physical* properties.

(α.) *Heat.*—It resists 100° C. in aqueous solution for a short time,†† but prolonged boiling for half an hour is said to destroy it.‡‡ This cannot be received without further research on the point since it is said on the other hand to have withstood several hours heating at over 100° C. Possibly different poisons have been employed.§§

(β) *Cold.*—On the other hand its activity is unaffected by cold.

(3.) *Chemical Properties of the Septic Poison.*—The poison itself, when isolated by different chemists, has been obtained in different degrees of purity, so that analyses of it must as yet be received with caution. The purest state that has been reached is probably that‖‖ in which deliquescent acicular crystals of sulphate of sepsin were obtained and which gave the symptoms of septic poisoning when introduced into the blood-stream. The crystals under consideration melted and burnt on platinum foil, giving off a smoky flame, and in solution (watery) gave the ordinary precipitates as an alkaloid, viz., with phospho-molybdic acid and potassio-mercuric iodide, platinic chloride, gold chloride,

---

* 43, 194.
† 18, 56.
‡ 43.
§ 18.
‖ 194, 112.
¶ 18, 247, 290.
** 247, 225.
†† 125.
‡‡ 130.
§§ 18, 112.
‖‖ 18, 247, 104, 56, 225, 250, 290.

tannic (white ppte.), mercuric chloride (a pink white ppte.). These reactions refer, of course, to the "alkaloid" obtained by a modification of the Stas-Otto process. An additional result has been observed* in the fact of the substance obtained, giving a violet colour with warm hydric sulphate, and possessing strong reducing powers. There can be little doubt of its nitrogenous nature, but it is not albuminous.

This description applies to the ptomaines, or poisons obtained from corpses.

A word may here be added with regard to a point, the importance of which has already been insisted on, viz., the probable difference between the alkaloids obtained from different sources and even from the same albuminous mixture. There is experimental evidence showing that the intensity of the poison depends on the extent to which the katalytic process has advanced.†

As a means of distinguishing between the vegetable alkaloids and the animal ones, or ptomaines, the employment of ferricyanide of potassium has been suggested,‡ which is said to be unaffected by vegetable alkaloids but reduced at once to the ferrous salt by ptomaines.

(*b.*) *Dose.*

As the substance has been investigated in varying degrees of purity, so the dose has been found to vary and it is not yet possible to draw up a table to show the proportion existing between the body weight and the amount of poison required for a fatal dose.

But the question of dose also opens the question of susceptibility and immunity. There is a wide difference among animals with regard to the former of these points and this would seem to depend to some extent on their diet, since those animals which are in the habit of devouring substances often the seat of septic change show a greater resistance to the ill effects of sepsin than animals comparatively clean feeders, such as rabbits and white mice. The similarity in the degree of resistance offered by animals to the chemical poison to their resistance of the mycotic process is very striking, and the power of immunity is probably similar in both cases.

Provided that the view of the alkaloidal nature of sepsin is confirmed, it is readily conceivable that by frequent inoculation of the pure substance, animals would develope a certain amount of power of resistance against its action, just as a tolerance of morphia or other alkaloids is soon arrived at.

(*c.*) *Effects*— (1) General, (2) Local.

(1.) General Effects.—Before discussing the general effects of the injection of sepsin, it is absolutely necessary to review the possible fallacies of observation in such an operation. Apart from the variation in temperature caused by the operation, and which exercises no important influence on the result, there comes the main question, What is the result of injecting fluids into the blood stream of an animal in ordinary health, and that not lowered by previous bleeding? It has been found§ that the injection of various "neutral" fluids is always followed by a distinct rise in temperature, and this was even the case when the injection took the form of an artificial arterio-venous aneurism in the same animal, the crural artery being peripherally connected with the central end of the crural vein.‖ In other words, interference with

* 250.
† 272.
‡ 39.
§ 1, 23, 18.
‖ 1, 137.

the metabolism of the parenchyma tissues always produces pyrexia, a simple proof of which is offered in the experiment of first bleeding an animal and then injecting blood serum.*

In subcutaneous injections the first effect is a slight lowering of the temperature, the normal height of which is soon regained, the substances employed being spring water and pus.†

A very interesting observation‡ showed that animals (rabbits) when narcotized by morphia, alcohol, or quinine, remained without fever after injection of putrid substance into them, apparently confirming the idea that the pyrexia is brought about indirectly through the agency of the nervous system.

Again, there is a possible error in the observation of rigors, viz., as to the time of their onset, for they may be produced by the sudden influence on the nervous system of the injected mass, this occurring even during the operation,§ and probably are not of septic character.

Finally, the temperature curve has been described as inconstant in shape, &c., but as the author‖ who advanced the observation mixes the results of injecting different fluids, the following facts may stand as true, subject to the precautions mentioned above.

The characters of the fever consequent on the introduction or absorption of the chemical septic matter are fairly well marked and exhibit experimentally the following stages:—(*a*) Latent period; (*b*) nerve symptoms and rigor; (*c*) rise of temperature; (*d*) loss of power and body weight, with diarrhœa; and (*e*) fall of temperature.

(*a.*) *Latent Period.*—The interval between injection of sepsin and the first symptom has been variously stated according to the method employed. The source of the poison also being different, the "alkaloid" in each case probably varied just as the cinchona alkaloids vary in their action. Moreover, it differs according to its concentration; thus, in the ordinary intravascular injection of putrid material there may be an interval of some minutes, during which the animal appears depressed, often uneasy and restless, before vomiting, &c. sets in.

(*b.*) *Nerve Symptoms and Rigors.*¶—The first prominent evidence of septic poisoning following an introduction of the alkaloid is revealed by vomiting and nausea. Evidently the medulla oblongata is the first part of the nervous system to suffer important derangement, and more especially the vagal nuclei and the allied motor centres which complete the cycle of reflex vomiting. That the process is essentially one of increased reflex excitability, the increase being peripheral as well as central, we see from the fact that, although in the latter stages (from loss of fluid, as will be seen), the subject of experiment becomes very thirsty, the introduction of fluid into the stomach at once causes an attack of retching and vomiting. The vomit presents the ordinary bile appearances if the stomach is empty. Coupled with the vomiting is the usual excessive secretion of saliva and ropy mucus from the mouth and pharynx.

The next centre to be affected is that of respiration, and mainly the inspiratory side. Thus the inspirations become deeper and accelerated, often being accompanied by a whining noise.

Then the cardiac pulsations rise in number, and this change is developed rapidly, thus in some cases the pulse at the end of half an hour could not be counted. In a less severe case they are found to rise with each effort of vomiting.

---

* 4*a*.
† 235, 277.
‡ 168.
§ 52.
‖ 140.
¶ 43, 194, 18.

The cerebral derangement noted in the latent period now becomes more apparent, and at the end of an hour shows itself as drowsiness and stupidity. At the same time the hind legs become weak, and this paraplegia is the expression of a general poisoning of the nervous system.

The further course of these symptoms is simply that of steady increase in extent, coupled with decrease in severity as the strength becomes exhausted. Thus the respiration becomes very shallow, the pulse very small and rapid, cardiac paralysis,* and a state of general paralysis ensues.

While the above phenomena are becoming marked, shiverings and definite rigors, lasting some minutes, are observable, not very constant in their extent or persistence, but rarely, if ever, absent. Coupled with this condition is horripilation.

A watery solution of the crystalline sepsin dropped into the eyes of rabbits and dogs dilated and paralysed the pupil.† Paralysis of the intestinal wall has also been noticed.

(*c.*) ***Pyrexia.***—A full discussion of this phenomenon would be out of place in a report of this kind, so that, after guarding against the fallacies mentioned above, we may consider the average amount of pyrexia and its mode of onset and disappearance. Whatever be its cause, it is an increased oxidation, and has been surmised‡ to be a process analogous to the separation of oxygen from hydroxyl by sepsin.

The rise and fall of temperature following one injection will (provided the dose be not very severe) occupy a space of about five or six hours, but the condition following the daily administration of a moderate dose will give a remittent pyrexia of evening rises, the state of things no doubt occurring daily in septic wounds.

The curve figured in Plate III. curve 3, is constructed mainly from Bergmann's tables, but it must be remembered that the dose he employed was often 16 cc. In reviewing the tables given by all the authors, the constancy with which the final stage in a fatal case is marked by collapse and fall of temperature (even to 35° C. §) is remarkable, only a very few instances (three or four) of rise of temperature at death being recorded out of more than 100 tables examined. Compare the curve of "septic fever," Pl. IV.

(*d.*) ***Diarrhœa and Loss of Weight.***—The loss of power is referred to under the nerve symptoms, and the gastro-enteritis set up now shows itself, first, as mucous diarrhœa, tenesmus, and later on intestinal hæmorrhage, and expulsion on straining of blood-stained mucus. The diarrhœa is apparently proportional to the dose of sepsin.‖

Emaciation and loss of weight is extremely marked in cases of chronic poisoning, or where the dose, though fatal, has not killed under 48 or 56 hours. Even in rapidly fatal cases in the last stage of collapse, from the relaxation of the tissues, the skin hangs in folds, and presents the appearance of emaciation.

(*e.*) ***Fall of Temperature and Collapse.***—The final stage of acute chemical poisoning is marked by profound collapse, the pulse becoming indistinguishable, the respirations sighing, and at intervals, until death occurs, sometimes with slight convulsions.

---

* 47.
† 290.
‡ 219, 132.
§ 18.
‖ 18, 130*a*.

(2.) Local Effects of inoculation of septic chemical poison.—Introduced beneath the skin, it produces a local inflammation the extent of which varies directly with the dose;* it thus seems to behave as a simple chemical irritant, and probably this considerable difference is due to difference in the alkaloid employed, since a gangrenous state has been observed to follow the subcutaneous injection of moderate doses.†

(*d.*) *Changes produced in the Tissues and Organs.*

Blood.—Slight icterus. Blood fluid and laky, but sometimes coagulates in black clots.

That blood containing a saprophyte should be poisonous is not extraordinary, and that the fact of the blood being so extremely active in experimental septicæmia does not surprise us; but it has also been shown‡ that the blood of animals poisoned by ptomaines is also poisonous. This rests, however, on but a few observations.

Serous Membranes.—Hæmorrhages common beneath all the serous membranes, but most common perhaps beneath the visceral layer of the pleura, and especially between the lobes of the lung and over the posterior surface of the lower lobe.

Hæmorrhages beneath the endocardium are found in the left side and almost invariably ventricular. The similarity of this limitation to the similar destruction by endocarditis (rheumatic) is very striking; and while on this point we may refer back to the question of ulcerative endocarditis briefly noticed at p. 248.

Peritonitis with brown albuminous flaky exudation may result.

Alimentary Canal.—The affection of the intestinal tract calls for special notice. It is seen at once to be involved very shortly after the introduction of the poison, and it is actually shown as hyperæmia in as short a time as five to ten minutes after the inoculation of the poison.

The hyperæmia does not affect the middle portion of the intestines so severely as the rest of the tract, and Peyer's patches often stand out as particularly involved. The mucous membrane is covered with red blood-stained mucus, and sometimes the lower end of the bowel contains liquid blood, often scarcely altered. Washing the mucous membrane reveals the presence of numerous hæmorrhages similar to those seen beneath the serous membranes. In chronic cases there may be ulceration over these hæmorrhagic areas, the intense inflammation there being analogous to the acute pleurisy found over the small subpleural hæmorrhages.

The liver and spleen are swollen and hyperæmic (the kidney also). Hæmorrhages are less common than in the situation mentioned above, but the spleen in addition is often almost diffluent.

V.—Antiseptics.

Although bearing indirectly on the main questions treated above it will be practically useful to refer to the research which has been conducted§ on the property that certain substances possess. There is very close agreement as to the proportionate value of the different antiseptics, and as the following table is the latest, and seems to be the most accurate,‖ it is here reproduced. The method in all was

---

* 130.
† 248.
‡ 65.
§ 41, 65, 66, 160*a*.
‖ 41.

the same, viz., an attempt to see what proportion would prevent the development of the ordinary bacteria of decomposition.

Mercuric chloride	- $\frac{1}{20000}$	Salicylate of soda	- $\frac{1}{250}$
Thymol -	- $\frac{1}{2000}$	Carbolic acid -	- $\frac{1}{200}$
Benzoate of soda	- Do.	Quinine -	- Do.
Creasote -	- $\frac{1}{1000}$	Hydric sulphate	- $\frac{1}{151{\cdot}5}$
Thymianol -	- Do.	Boracic acid -	- $\frac{1}{133{\cdot}33}$
Carrol -	- Do.		
Benzoic acid -	- Do.	Cupric sulphate	- $\frac{1}{173{\cdot}33}$
Methyl salicylic acid	- Do.		
Salicylic acid -	- $\frac{1}{666{\cdot}6}$	Hydric chloride	- $\frac{1}{75}$
Eucalyptol -	- Do.	Zinc sulphate -	- $\frac{1}{50}$
Caraway oil -	- $\frac{1}{100}$	Alcohol -	- Do.

VI.—Resumé.

In the foregoing account care has been taken to avoid describing any point (in connexion with the physiology of the septic organisms) which does not rest on direct experiment, and hypothesis is introduced solely to render the meaning of an experiment here and there a little clearer. For this reason much has been omitted as not proved to be owing to the life changes of the organism, and this was especially necessary with the details of the fermentative or katalytic process, since a review of that question would have occupied as much attention as the whole subject of the septic poison. But reference may here be made to this much vexed subject of debate in its important practical bearing with reference to one fact which comes out as a deduction from the foregoing account and has recently* been established on an experimental basis. It is that *both unorganised ferments and the organisms here described are subject to the same physical laws*, since their potentiality of action is not destroyed by cold, and that (what is more striking) if placed in water, it is annihilated at 50° C., but that if dry, will survive a temperature of 135° C.; and let us add to this as a rider the observation† that the products of unorganised and (so-called) organised ferments are apparently identical.

From these facts it is very tempting to draw the inference that (as the existence of the unorganised katalytic agent is a positive fact, and as the fermentation influence of a low organism is as yet not proven), the ferment is in every case an unorganised compound capable of causing molecular disruption. Supposing this inference to be justifiable its importance in the pathology of septic poisoning is obvious.

It is noteworthy as regards this point that even Pasteur has so far modified his theory with regard to the torula cerevisiæ as to consider that the actual ferment may be unorganised, though dependent for its origin on the torula. With the analogous cases of spongy platinum, superheated steam, &c. it is not difficult to conceive that the "septic" process is always a chemico-physical process, and not a biological one, *i.e.*, as far as the decomposition of the albuminoids, &c. is concerned; while on the other hand it is difficult to understand how an organised form could exert *per se* a definite action on any compound, except

* 122. † 117.

indirectly, just as the gastric protoplasm only converts albuminoids by the indirect method of peptonisation.

The classification of the varieties of blood poisoning given on pp. 240–1. is based on the supposed causes of the same, and not on the symptoms produced. This somewhat unusual arrangement needs a little further exposition, although all the ascertained facts bearing upon it are enumerated under their respective headings.

The first point obviously is to proceed from the best known to the more uncertain, and therefore the application of the classification may first be examined as regards sapræmia.

Sapræmia has been so fully discussed as to need only a short examination of its occurrence in the human subject. Reference was made on p. 248 to the non-discovery of organisms in cases of acute septicæmia, and to the belief that these were cases of sapræmia. Now putting aside severe instances, there can be but little doubt that the listlessness, headache, loss of appetite, and evening rise of temperature to 1° or 2° in cases of wounds, &c. in which the discharge is fermenting, means that a daily absorption of sepsin is going on, and unless arrested will carry off the patient either by exhaustion or by sudden exacerbation. It is not so easy at present to understand the possibility of acute sapræmia occurring in a small wound, but the fatal dose of the pure alkaloid is not yet accurately ascertained, so that nothing can be decided either way. Passing now to the second form, which we have termed mechanical mycosis. Considering the rapidity with which organisms multiply, and viewing the condition of the blood vessels in such affections as anthrax, acute experimental septicæmia, &c., it would seem that in these cases the organisms may cause symptoms by mere mechanical arrest of the ordinary nutrition processes from their immense number in proportion to the calibre of the vessels (see fig. 15). Such a cause of death may also find an example in cases of general infection by one of the hyphomycetes, such as has already been recorded as occurring in man* (Penicillium), and has been the subject of experimental investigation (see p. 250). Supposing that the organisms found in the subject of disease are the actual cause of the symptoms, it is obvious that their action may depend on either destruction of the host, or a more rapid process, viz. the manufacture of sepsin in the tissues: the former of these we have termed the destructive, the latter, the formative variety. As before mentioned, the fact of the occurrence of an organism proves nothing *per se*, so that if in cases where the mass of organisms is not sufficient to warrant the supposition of a mechanical mycosis, formative biological mycosis is as yet an idea.

So much, then, for the chemical sapræmia, and the mechanical variety of mycosis. Now, let us examine the third kind of "septicæmia," premising, of course, that mechanical mycosis cannot occur without the destructive kind of biological mycosis being also marked to a greater or less degree.

From this point of view alone the bacillus anthracis can only be considered as poisonous and bacillus subtilis as harmless, because the former is able, the latter unable, to grow in the blood. But that the destructive variety of the biological mycosis occurs is also a reasonable inference from the fact of the organisms living in the blood, and from their rapid development therein, necessarily splitting up and assimilating those elements of it which are requisite for their existence. But little direct experiment has been employed to elucidate this most important point, and what is actually known is referred to on pp. 260–2 in discussing the action of organisms on living tissues.

* 124*a*, &c.

With this uncertainty in the more obvious kind of biological saprophysis it is easy to understand that of the formative variety of the biological mycosis there is no direct proof, and it is an inference drawn from those cases where an organism is found, but not in such quantity as to admit of the supposition of the mechanical mycosis or sufficient to support the idea of a destructive saprophysis.

In pursuing the supposed action of organisms in producing disease we are struck by the want of direct experimental evidence contrasted with the investigation of sapræmia, so that the summing up necessarily leaves the second and third kinds of septicæmia as matters of opinion.

Fully realizing the scientific weakness of the present knowledge, an attempt may be made to apply the above possible hypotheses to illustrate the human septic diseases, septicæmia and pyæmia.

Septicæmia in man as ordinarily understood (*i.e.*, the symptoms of chemical septic poisoning only spread over a comparatively long interval of time, and post-mortem evidenced by only a few of the changes described above) may be considered as occurring in an acute and chronic form. The former of these kills in three or four days, the latter may extend over a fortnight. On the supposition, first, that this is a sapræmia, we have the fact of the symptoms beginning with the commencement of the decomposition in the wound discharge, the intense character of the same, and the prominence of nerve symptoms.* Unfortunately we are unable to add the one fact which would tend to settle the question, viz., the existence or not of organisms in the blood. It is somewhat extraordinary that systematic investigation is not always made into every case of septicæmia in hospitals, considering that if this were only carried out thoroughly even for a year, the information on the one subject now most important to the operating surgeon would be well-nigh complete.

The chronic form has been referred to before, and differs from the other in duration and severity, probably owing to the difference in resisting power of the patient attacked, and other conditions dependent on the wound.

Pyæmia.—The frequent discovery of micrococci in this affection justifies us in considering what kind of mycosis this usually is, obviously not mechanical, and so probably is to be referred to the third kind of blood poisoning, or "septicæmia," but no more ought to be said on this point with our present information.

It may make the sense of the foregoing a little clearer if we introduce here a sketch of the method of investigation into the nature of a case believed to be one of "septicæmia."

Since the absence of organisms proves more than their presence, the process will better commence with inquiry in this direction.

1. Blood to be examined for organisms
   - Unstained
     - Unaltered.
     - After addition of KHO, ether, &c.
   - Stained by Weigert-Koch method.

The blood is to be examined at both the high and low points of the patient's temperature, and once during the night and day.

2. Excreta to be examined in the same way (especially the urine).

A. Their total absence precludes the possibility of a *mechanical mycosis* and *destructive* variety of the *biological mycosis*, while tending also to negative strongly the idea of a *formative biological mycosis*. This doubt with regard to the last would be eliminated on further watching the case and still noting absence of organisms.

* See the typical case given in the chart.

3. Organisms found in blood.

(*a.*) Blood to be examined on warm stage - { Activity of organisms noted and possibly development. Proportion of organisms to quantity of blood. Blood prepared by Weigert-Koch method.

(*b.*) Changes in character of blood to be noted.

(*c.*) Excreta examined.

(*d.*) Inoculation on animals. (Same species to be invariably employed.) *a*, *b*, *c* to be observed in subjects of experiment.

B. The size of the organism, its proportion to the effects observed, will separate *mechanical* mycosis from the other varieties of saprophysis.

4. No organisms found in the blood, &c.

(*a.*) Freshly drawn blood to be examined at once by modified Stas Otto process.

(*b.*) Observation of prominent nerve symptoms.

(*c.*) Inoculation of lower animals with blood of patient.

(*d.*) Action if any of blood on pupil.

C. Supposing these tests to yield positive results to those indicated in the text the diagnosis is completed.

It remains only to point out the gratifying fact that many fundamental points are fixed with almost absolute certainty, owing to so very many observers having worked on precisely similar lines, so that old points have been thoroughly threshed out rather than new ones discovered. With the stirring advice of Professor Panum, "Muss man "vor allen Dingen den Forderungen der Logik genügen und Punkt für "Punkt durch streng wissenschaftliche Untersuchungen aufzuklären "suchen,"—before us, we may hope that the same energetic research will continue, with the elucidation of "septicæmia" as the wished-for consummation.

Note.—Of the numerous authors whose work has elucidated the points of reference in the text, those only are mentioned who discovered or shed most light on the question discussed.

VII.—Method of investigating presence of Organisms.

The methods employed are dependent upon: (1.) The resistance offered by the cellulose coat of the organism to the action of the ordinary reagents; (2.) Upon their property of being readily stained by the aniline dyes; and (3.) Their growth in cultivating fluids, and in living tissues. A short abstract of the methods is here appended:—

(1.) The possible sources of error in searching animal fluids, &c. for organisms lie in the fact of the close resemblance between coccus forms and small granules of fatty and albuminous nature. Acicular crystals also sometimes slightly resemble rod forms. All these are separated with ease, since they can be destroyed by the action of potash and ether, leaving the organisms uninjured.

(2.) The reaction of the different organisms to staining fluids is certainly different, but too much stress cannot be laid on this point at present. The dyes of most use are hæmatoxylin, methyl violet, methylen blue, gentian violet, Bismarck brown, vesuvin, &c. Of these the second is one the most useful for ordinary purposes, and the brown for photography. The strength of the solutions employed have been varied, but solutions from ·5 °/₀ to 1 °/₀ will be found to be practically the best. The investigation differs according to the tissue.

Blood and Pus.—A thin layer is spread upon a cover glass, then immediately dried by a few rapid passes over the flame of a Bunsen gas-burner, or, if that is impossible, over a spirit flame. As soon as quite

dry, a few drops of the dye solution is poured over the film and left on for a minute or more, then gently washed off with distilled water and allowed to dry. Finally, a drop of (previously heated for some hours) hard Canada balsam is fused on a slide, and the cover glass with the stained film of blood inverted upon it, and pressed down.

Cautions.—(*a.*) It is scarcely necessary to add that the skin of the subject of observation and all glass work must be cleaned with alcohol and distilled water before blood, &c. is drawn, and that the glass must be passed several times through the flame immediately before use. (*b.*) The manipulation from the time of collecting the fluid on the cover glass to the moment of staining must be conducted as rapidly as possible; the film once dried and stained, can be kept without fear of error, since adventitious organisms would not be coloured. (*c.*) Care must be taken not to over-heat the film either on the first or final occasions. (*d.*) If staining is prolonged and washing conducted roughly, the film may be easily washed away.

Tissues.—Organs, &c. to be hardened in absolute alcohol. Extremely thin sections are then to be prepared, placed in methyl violet for 15 minutes, or Bismarck brown for 24 hours, or double staining may be employed. The sections are then placed in a watch-glass of water, to which one or two drops of acetic acid are added, or in a 5 $^{0}/_{0}$ solution of carbonate of potash. The sections become decolorised, and slightly swollen. Now they are placed in absolute alcohol; the coloring matter dissolves out rapidly in this medium, so that care must be taken to pass them quickly into oil of cloves, and mount in balsam before the staining has disappeared. These details only require a little practice which no words will supply.

Organisms may be detected during life in transparent membranes, mesentery, &c.

Cultivation and Inoculation.

(1.) *The cultivation* fluids that have been employed are numerous, and include Pasteur's and Cohn's formulæ, both well known. But more lately the mode of growth of organisms has been studied with great advantage by inoculating some of the fluid on the clean-cut surface of a boiled potato. Although organisms rapidly appear in many places on the cultivation surface, still each organism keeps within its own territory, and so the cultivation is practically pure.

But also the method of observing the growth of organisms in animal fluids such as peptone solutions, serum, &c., has been facilitated by adding just sufficient gelatine to ensure the solidity of the cultivation mass at ordinary temperatures. This compound can be poured (heated) on clean slides and inoculations made on the surface at different points, the organisms growing from each inoculated point, and readily watched with the microscope power up to 300–400 diameters.

(2.) Inoculation may be practised in various ways: (*a.*) By placing a drop of solution on slight wound surface (vaccination), or by injection into the blood stream by a vein, or into the lymph system by introducing the liquid into the peritoneal cavity. Further, the growth of organisms may be observed in the cornea after inoculation by a small puncture.

Since the methods vary so much, only the general principles on which they are founded, together with a few details, are here given. Especially necessary is this the case, since organisms accustomed to one preparation do not readily grow in another.

VIII.—Literature.

Note.—Those authors whose names are indicated by an asterisk have written more especially on the chemical side of the question, and those authors who are referred to only by name are quoted here on account of their being credited with facts mentioned in the text, but the original publication of which it has been impossible to find.

A.

1. Albert, u. Stricker.—Untersuchungen ü. d. Wundfieber. Wiener Med. Jahrb., Heft 1, s. 39–69.
Also, Wochenblatt d. Wiener Aerzte. No. 28, s. 290, 1871.
2. Anders.—Die Giftige Wirkung d. d. Bact. Vegetation in Pasteursche. Naturflussigkeit. Deutsche Zeitschrift. f. Chirurg. Bd. VII., 1876.
3. Anstie.—Pyæmia. Lancet, Jan. 22nd, p. 117, 1870.
3a. Arloing, Cornevin Thomas.—Comptes Rendus, t. 89, 1880, p. 1300. (Charbon Symptomatique.)
4. Arndt.—Virch. Archiv. Bd. 82, p. 119.
4a. Assmuth.

B.

5. v. Babes. (Die Pathogenen Bakterien.) Biologisches Centralblatt. Ap. 15, 1882. Buda-Pesth, 1881.
6. Balfour.—Pyæmia. Edin. Med. Journ., Oct. 1877.
7. Balogh.—Spherical Bacterien im d. Entzundete Hornhaut. C.-blatt. f. Med. Wissenchaft, No. 6, 1876.
8. Baltus.—Montpellier Medicale. Oct. 1874.
9. Barnes.—Conveyance of Zymosis. St. George's Hospital Reports VII., 1875.
10. Bartold.—Pyaemische Metastasis. Diss. Berlin, 1875.
11. Barwell.—Septic Diseases. Med. Chirurg. Transactions, vol. 57, 1874.
12. Bastian.—Brit. Med. Journal, 1872, p. 582.
—— Also, Origins of Life. Proceedings Royal Society, 1876, p. 177.
—— Proceedings Royal Society, 1873, No. 145.
—— Transactions of Linnean Society.
13. Baumgarten.—Centralblatt f. Med. Wissensch. Ap. 15, 1882.
14. Beale.—Disease Germs. London, 1872.
15. Bechamp.—Montpellier Med., tome XXIV., Jan. 1870. Compt. Rend. 65, p. 850.
—— Bulletin de l'Acad., tome XXXV., p. 368.
—— Les Microzymas, 1875.
16. Behier.—Bulletin de l'Acad., 1873, p. 148.
17. Bergeron.—Sur bacteries dans l'Abcès. Compt. Rend., tom. LXXX., No. 6, 1875.
*18. Bergmann.—Das putride Gift. I. Abtheile, 1868. Zeitschrift für Chir., iv., 1875.
—— Zum Lehre von d. putrid Intoxication, 1872; (u. Schmiedeberg) C.-blatt. f. Med. Wiss., No. 32, 1868.
—— Petersburg Met. Zeitschrift.
19. Bergnier.—Ein. Beiträg. z. Kenntniss d. blaue Schw., Petersburger Med Zeitschrift. Bd. XIV., 1868.
*20. Bert.—Compt. Rend., tome LXXXIV., No. 21, 1877.
—— „ „ „ LXXXV., No. 5, 1878.
21. Bettelheim.
22. Billroth (u. Ehrlich).—Untersuch. ü. Cocco.-bacteria Septica. Archiv für Klin. Chirurg. Bd. XX., Heft 2, s. 403, 1876.
—— U. Coccobacteria Septica. Berlin.
23. Billoth.—Beobachtung u. Wundfieber. Archiv f. Klin. Chir., Bd. IX., Heft 1, s. 52, 168.
—— Beobachtung. u. Wundfieber. Archiv f. Klin. Chir., Bd. XIII., s. 579. 1872.
24. Binz.—Centralblatt f. Med. Wiss., 1867, No. 20.
25. Birch, Hirschfeld.—Untersuch. u. Pyaemia. Archiv d. Heilkunde, Bd. XIV., 3, 4, p. 193, 1873.
—— Bakterien in Blut. Pyaemische. C.-blatt. f. M. Wiss., No. 39, 1872.
—— Schmidt's Jahrsbucher Jahrgang, 1875.

26. Blum.—Etudes sur la pyohemie. Arch. gen. d. Medec., Oct. 1870.
—— Etudes sur la fievre traumatique. Archiv gen., p. 414, 1869. Also, p. 534.
—— Etudes d. coccobacteria septica. Clin. Archiv Strasbourg, 1871.
27. Bochefontaine.—Bulletin de l'Academie, 1873, p. 512.
28. Borel.—Quelques mots sur la nature et val. de parasites microscop. Correspondenz blatt. d. Schweizte, Aerzte. Jbgang. VII., No. 12, 1877.
29. Botkin.—Berlin, 8, 1874.
30. Bouley.—Bulletin de l'Academie, 1873, pp. 84, 508, 519, 562.
31. Bouloumié.—Recherches sur l'influence des microzymas. Compt. Rendus, tom. LXXX., No. 2.
32. Bouyer.—Observ. de Sept. L'Union Médicale, No. 53, 1873.
*33. Boyer.—Gazette Medicale, March 29, 1834.
34. Bradley.—Septicæmia. Lancet, May 27th, 1876.
35. Braidwood.—Pyæmia. London, 1869. Brit. Med. Journ., Nov. 4, 1876; (and Vacher) Brit. Med. Journ., Feb. and March 1877. Also, June 24, 1876.
36. Brauell.—Virch. Archiv., Bd. XIV., 1858.
*37. Brautlecht.—U. Fäulniss Producte. Allg. Wien. Med. Zeitschrift., No. 44. 1878.
38. Brehm.
*39. Brouardel and Boutmy.—Sur ptomaines. Le progrès Médical, May 14, 1881.
40. Brugnatelli.
41. Buchholtz.—Antiseptica u. Bakterien. Archiv. f. Exper. Pathologie, &c. B. IV., s. 1, 1875.
—— U. Einfluss d. Temperature auf Bakterien. Ebend., B. II., s. 159.
—— Beitrage für Kenntniss Ernährungs erhaltniss d. Bakterien. Eben., B. VII., s. 81, 1877.
42. Buchner.—U. du Wirkungen d. Spaltpilze im Lebenden Körper. Munich, 1881.
—— U. d. Experimentelle Erzeugrung d. Milzbrand Contagiums aus d. Heupilzen. Munich, 1880.
43. Burdon-Sanderson.—Brit. Med. Journ., 1875.
—— Patholog. Transactions, XXIII.
—— Quarterly Microscop. Journal, Oct. 1871.
—— Reports to the Medical Officer of the Privy Council.
44. Butlin.—Proceedings of the Royal Society, 1879.

C.

45. Cadge.—Pyæmia. Brit. Med. Journ., Ap. 22, 1876.
46. Cane.—Lancet, June, 1875.
47. Cavafy.—Injection of Putrid Fluids into lymph sacs of Frogs. St. George's Hospital Reports, VII., 1875.
48. Carter.—Spirillum in relapsing fever. Lancet, June, 1877. Also, Spirillum Fever. 1882.
*49. Cech.—Sur Kenntniss a. Zersetzungs Processes im faulenden Hühnerei. Journal f. Prakt. Chemie., Bd. 130, 1880, p. 338.
50. Champonnière.—Sur la fièvre traumatique, 1872.
51. Chauffard.—Fièvre traumatique et l'infection Purulente. 1874, Gaz. Hebdom.
52. Chauveau.—De l'agence pyrogenique. Gaz. Hebdom., No. 37, 1875, &c.
53. Cheyne.—Pathological Transactions, 1879, p. 571.
54. Chiene.—Journal of Anat. and Physiol., vol. 13, p. 448.
55. Clemens.—Alcohol in Pyæmia. Det. Klin., No. 45, 1874.
*56. Clementi (and Thin).—Untersuch u. Putrid. Infect. Oest. Med. Jahrb. Heft 3, s. 293.
57. Cohn.—Beiträge z. Biologie a. Pflanzen. c. Mendlesohn. 1879.
58. Colmann v. Schaltenburg.—Case of Pyæmia. Mang. Diss. Gottingen.
59. Colin.—Recherches nouv. sur matière purulente et septique. Bulletin de l'Acad., No. 40 and 42, 1873. Bulletin d'Acad., No. 9, 1875.
60. Coze and Feltz.—Recherches experimentale sur la presence des infusoria dans les malad. infect. Strasburg, 1866.
61. Cunningham.—Aeroscopy. Brit. Med. Journ., Feb. 1874.
62. Curtis.—New York Med. Record, 1878.

D.

62*a*. Dallinger.—Quotes Downes and Blunt.
63. Daly.—Pyæmia in private. Lancet, Feb. 1875.
64. Dasara Cao.—Della Flebite, &c. Virch. Jahrbericht, 1873, p. 334.

65. Davaine.—Recherches sur quelque questions relatif à la septicæmie. Bulletin de l'Acad., No. 31–38, 1872.
—— Inoculation de matière septique. Ebend, No. 38, 1872.
—— „ „ „ Ebend, No. 45.
—— Compt. Rend., t. 84, p. 1322.
—— Gazette Medicale, 1874, p. 44.
—— Compt. Rend., t. XCIII., No. 24.
66. Demarquay.—De l'osteomydite. L'Union Medicale, 1871.
—— Bulletin de l'Acad., XXXVI., No. 19.
—— Comptes Rendus, t. LXXX., p. 22.
67. Desprès.—Chronique Pyohemie. Archiv. Gen. de Med., Sept. 1874.
68. Discussion sur Septicæmie. Bulletin de l'Acad., 1873.
69. Dolschenkow.—Impfung faulenden Substanzen a. Kaninchenhornhaut Centralblat. f. Med. Wiss., p. 655., 1873.
70. Donec.—Pyæmie sans Blessé. Thése, 1877.
71. Donovan.—Dublin Med. Journ., 1875.
72. Douglas.—Glasgow Medical Journal, 1878.
73. Dowdeswell.—Quarterly Journal of Microscopical Science. January, 1[illegible]. Also, Nature, February 21, 1878.
—— Quarterly Journal of Microscopical Science, p. 83, 1878.
*74. Dreyer.—U. Virulenz, &c. Archiv f. Exper. Pathologie, &c. Bd. 2. s. 149, 1874.
75. Drysdale.—Pyrexin. 1880, London.

E.

76. Eberth.—Virchow Archiv f. Path. Anat., Bd. LXII., s. 504.
—— „ „ Bd. LXV., s. 341, 1875.
—— Mycosis. „ „ Bd. LXV., s. 352, „
—— „ „ Bd. LXXVII.
—— Bakterien in Schweiss. Centralblatt fur Medecin. Wissenschaft, No. 2[illegible] 1873.
—— „ „ „ s. 11[illegible] 1873.
77. Ehrlich v. Billroth.
78. Eidam.—Beiträge z. Biologie a. Pflangen. Heft 3.
*79. Ekunina.—U. d. Saure Reaction a. Gewerbe na. d. Tode. Journal fur Prakt. Chemie., Bd. 129, 1880.
79*a*. Englemann.—Pflugers. Archiv, Bd. XXV., p. 285.
*79*b*. Erdmann.—Journal f. Prakt. Chemie., 1866, p. 385.
80. Erichsen (v. Heath).—Acute Septicæmia. Brit. Med. Journ, Oct. 17, 187[illegible].
—— „ „ „ March 14, 187[illegible]
81. Evans.—Pyæmia.
82. Ewart.—Proceedings of Royal Society, vol. XXVII., No. 188. Journal of Anat. and Phys. c. Cheiene., vol. 13, p. 448.
—— c. Geddes Proceedings of Royal Society, vol. XXVII., No. 189.
*83. Exner.—U. u. d. Entwickelung d. Ammoniak aus faulend. Blut. Sitzungsb. Wien Akad. d. Wissench. Abth. II.. Math. Natn. W. Klasse. July 3rd. 363, 1870.

F.

84. Fairfield.—Genesis of Bacteria in Urine. New York Medical Record. Aug. 24, 1877.
85. Fassbender.
86. Fayrer.—Edinburgh Med. Journal, Aug. 1877.
87. Feltz (and Coze).—Gazette Medicale a. Strasbourg, 4, 6, 10, 11, 1866.
Feltz.—Comptes Rendus. t. LXXVI., No. 22, 1873.
—— „ t. LXXIX., No. 22, 1874.
—— „ t. LXXX., No. 9, 1875.
—— „ t. LXXX., No. 21, 1875.
—— „ t. LXXXIV., No 16, 1877.
—— „ „ „ „ 18 „
—— „ „ „ „ 23 „
—— „ „ LXXXV., No. 6, 1877.
87*a*. Ferrier.
88. Fink.—Zu. Frage Pyaemie v. Septicaemie. Bair. Aertzte. Intelligenz blatt No. 6, 1873.

89. FISCHER.—Virchow v. Hirst Jahresberichte, p. 214, 1868.
—— „ „ „ p. 243, 1869.
90. FOKKER.—C.-blatt. f. a. Med. Wissenschaftes, 1880, No. 44. 1881, No. 2. Also, Virch. Archiv, 1882, April.
91. FORT.—Trois cas d'insol. de Infect. Purulente. Gaz. Medicale, No. 3 (?), 1871.
92. FRISCH.—Exp. ü. Fäulniss. Organ v. Gewerbe. Erlangen, 1874.
—— Milzbrand Bacterien ihre Vegetationen in Hornhaut. Sitzrungsbericht. a. Wien. Akad. Abth., Bd. LXXIV., 1877.
—— U. d. Einflus. Niedera. Temperature, a. d. Lebensfahigheit d. Bact. Sitzungsbericht a. Wein. Akad. Abth., B. LXXV. Abt. III., 1877.
93. FREY.—K. insensible Verlust Wundfiebers. Dorpat. Met. Zeit. III., 3 & 4, 1873.

G.

94. GAFFKY.—Mittheilungen. d. k. Gesundheitsamte, 1881, p. 80.
*95. GASPARD.
96. GOSSELIN.—Comptes Rendus, June 1875.
—— „ „ vol. 80.
97. GRAWITZ.—Beiträg. Virchow Archiv., Bd. LXX., s. 546, 1877.
—— „ „ Bd. LXXXI., s. 355.
—— „ „ Bd. LXXXIV., s. 87.
98. GREENFIELD.—See Report. Also Reports to Med. Officer to Local Govt. Board.
99. GREVELER (and HÜTER).—H. d. allgemein. Krieslauf nach Infection. Cent.-blatt. f. Med. Wissen., No. 49, s. 514, 769, 1872.
100. GRIM.—Z. Path. d. Milzbrandes. Virch. Archiv, B. 54, s. 262.
—— Sur Naturgeschichte d. Vibrionen. Archiv f. Mikroscop. Anat., Bd. 8, s. 514, 1872.
101. GRUN.—Sur nature. d. Vibrionen. Archiv f. Mikroscop. Anat., Bd. 8, s. 514 1872.
*102. GUÉRIN.—Ferments, etc. Compt. Rendus, t. LXXVIII., No. 20, 1874, pp. 81 & 782.
—— Role. d. ferments. Compt. Rendus, t. LXXX., No. 2, p. 81, 1875.
103. GÜTERBOCK.—Essai physiologique sur le pus, &c. 1838.
*104. GUNNING.—Middleburg. Journal f. Prakt. Chemié, Bd. 17, f. 266, 1878.
—— „ „ „ p. 434, 1879.

H.

105. HALLIER.—Schultze's Archiv f. Mikroscop. Anat. 11, pp. 67, 86. Leipsig, Engelmann, 1866.
—— Zeitschrift f. Parasiten kunde. Heft 2, Bd. II., s. 117, 1869.
—— „ „ Heft 1, Bd. II., p. 1, 1870.
—— „ „ „ 59–62, 1871.
—— Plastid. d. n. Pflanzen, &c. Leipzig, 1878.
106. HALSTEDT.—Septicæmia. Med. and Surg. Reporter, Philadelphia, July 17, 1875.
107. HAMMOND.
108. HAUSMANN.—U. d. Vorkommen, im Zahnsabscess. Berlin, Klin Wochenschrift, No. 14, 1877.
—— U. Vibrionen Parasiten. Inaug. Diss., Berlin.
—— U. prim Vorkomm. v. Bacterien in ein geschloss. menschlich. Ei. Virch. Archiv, Bd. LXVII., s. 11.
109. HAYEM.—Des embolies capillaires en pyohemie. Gaz. Hebd., No. 19, 1871. Société de Biologie. December, 1872.
110. HEIBERG.—Fall v. Endocard. Herzenmykosis. Virch. Arch., Bd. 56, s. 407.
——Puerp. u Pyaemi. Proc. Leipzig, 1873.
*111. HELMHOLTZ.—Ü. d. Wesen a. Fäuhnis u. Gährung. Müller's Archiv, 1843, s. 453.
*112. HEMMER.—Wirkung faulend. Stoff. Gekrönte Preis. München, 8, 170, 1866.
113. HENSEN.—Bemerk. zu. d. Aufsatze. u. Abstammung. u. Entwicklung d. Bact. Termo. Archiv fur Mikroscop. Anat., Bd. 3, 1867.
114. HEWETT.—Pyæmia in Private. Brit. Med. Jour., Jan., Feb., March, 1874.
115. HILLER.—Virch. Archiv, Bd. 62, s. 336, also s. 361.
—— Archiv f. Klin. Chirurg., Bd. XVIII., s. 669.
—— Centralblatt f. Chirurg., 1874.
—— „ „ 1876, Nos. 14 and 15.
—— C.-blalt. f. Med. Wiss., 1874, No. 21–24.
—— „ „ „ 53 and 54.

116. Hocum.—Bacteria in Urine. New York Med. Record, Sept. 22, 1877.
116*a*. Hoffmann.—Wien. Med. Wochenschrift, No. 13, 1873.
*117. Hoppe-Seyler. Med. Chem. Untersuch. Tubingen. Heft 4.
—— „ Physiol. Chemie, Bd. 1, p. 116, 1877.
118. Horsley and Mott.—Journal of Physiology, vol. III., No. 3.
119. Horvarth.
120. Huber.—Deutsches Archiv f. Klin. Med., Bd. XXV., s. 240. (Massenerkrangen.)
*121. Hüfner.—Journal fur Prakt. Chemie., B. 13, p. 475, 1876. Also, 1875. p. 43, p. 194. With Marchwort, ec. do. 1874, pp. 148, 385.
*122. Hüppe.—Chem. Centralbl. 1881, 745.
123. Hüter.—D. Allgemeine Chirurg. Leipzig, 1873.

I.

124. Ihlder.—Faülniss, Erscheinungen. C.-blatt f. Medicin Wissenschaft, No. 29
124*a*. Israel.—U. s. n. Erfahungen a. d. Gebiete d. mykose, &c. Berlin, Klin. Wochensf., No. 49, 1878.
—— Neue Beobachtungen, a. a. Geb. d. mykose. Virch. Archiv, Bd. 74. p. 15.

J.

125. Jeannel.—Sur l'Infection purulent ou Pyohémie. Paris, 1880.
*126. Jeanneret.—Zersetzung v. Gelatin, &c. Journal f. Prakt. Chem. Bd. 123, 1877, p. 353.
127. Jessop.—An Outbreak of Septic Fever. Med. Times and Gaz., Sept. 1873.
*128. Joubert et Pasteur.—Compt. Rend., t. 85, p. 101, 1877.

K.

*129. Kaufmann.—U. d. Zersetzung d. Blutes d. Bacillus subtilis. Journal f. Prakt. Chemie, Bd. 125, 1878, p. 71.
*130. Kehrer.—U. d. putrid Gift. Arch. f. Exper. Pathol., Bd. 2, s. 33.
130*a*. Kettler.—Thèse. Dorpat.
131. Klein.—Reports to the Medical Officer of Privy Council and of Local Government Board.
—— Quarterly Journal of Microscopical Science, vol. XV., p. 381.
132. Klebs.—Die pyrogene Substanz. Centralblatt f. Med. Wissenschaft, No. 3, 1868.
—— Der Ursach. d. Infect. Virchow u. Hirsch. Jahresbericht, p. 2, 1871.
—— „ „ Archiv f. Experiment Pathol. Bd. . p. 350; Bd. 4, s. 207; Bd. 4, s. 409.
133. —— u. Tommassi.
134. Koch.—Beiträge z. Biologie d. Pflanzen. Aetiologie a. Wundkrankheiten. Leipzig, 1876.
—— Mittheilungen aus d. Kaiserlichen Gesundheitsamte. 1881. (Their communications on Pathogenous Organisms.)
—— D. Artiologie d. Tuberculose Beul. Klin. Wochenschr. 1882. No. 15
135. Kocher.—Berne.
136. Koester.—Embolisches endocarditis. Virch. Archiv, Bd. 72, s. 257, 187[illegible]
—— „ „ Dorpat, 1877.
137. Köhler.—Septic Infect. Virchow und Hirsch. Jahresbericht, 1877.
138. Kolaczek.
139. Koster.
140. Küssner.—Centralblatt f. Med. Wissenschaft, 1870, p. 498.

L.

141. Laborde. Septicaemie Experimentale. Gazette Médicale, No. 6, 1874.
*142. Lacassaigne.—De la Putridité morbide et septique. Montpellier, 1872.
143. Lancet.—Sept. 1872. Sept. 18, 1867. 11, 7, 1866.
—— No. 30, 1872.
—— June 8, 10, 24, 1871.
144. Landan.—Zum Aetiologie d. Wundkrankheitens. Archiv f. Klin. Chir. Bd. 17. Heft 4, s. 527, 1874.

145. Lankester.—Quarterly Journ. of Microscop. Science, vol. XIII., p. 408.
146. Leber.—Entzündung d. Hornhaut. C.blatt. f. Med. Wissensch., No. 9, 1873.
147. Lee.—Decomposition of Blood in Living Vessels. Med. Press, July 3, 1872.
*148. Lefort.—Mémoire sur Phosphates en Putrifaction. Bulletin de l'Acad., No. 8, 1874.
149. Lemaire.—Compt. Rend., t. LVII., p. 625.
—— „ „ t. LIX., p. 317.
150. Leplat (et Jaillard).—Compt. Rend., 1864, p. 250.
151. Letzerich.—Experiment. Untersuch. Virch. Archiv, Bd. LXVIII., s. 519.
—— Mycosis Oesophag. Archiv f. Exper. Pathol., Bd. VII., s. 223, 1877.
152. Leuret.
153. Levitsky.
*154. Lex.—U. fermentwirkung d. Bact. C.blatt., 1872, p. 291, 305, 513.
155. Lewis.—Organisms found in Blood of Man, &c. Calcutta, 1879.
156. Livon.—Inject d. bacteries d. l. sang sans effét. Gaz. Med., No. 33, 1877.
*157. Lister.—Quarterly Journal of Microscop. Science. Oct. 1873. Lancet, 1867, pp. 95, 353, 668.
—— Transactions R. S. Edinbro', v. XVII., 1875.
158. Loew u. Naegeli.—Journal f. Prakt. Chemic., 1880, p. 97.
159. Löffler.—Mittheilungen d. K. Gesundheitsamte. 1881, p. 134.
160. Lombroso.
160a. Longstaff.—Sanitary Record.
161. Lortet.—Les Végétaux parasites. Annales de Darmotologie, No. 1, p. 29.
162. Lostorfer.
163. Lüders.—U. Abstauung u. Entwick. d. Bact. termo. Archiv. f. Mik. Anat., Bd. 3. 1867.
164. Lukomsky.—Erysipelas. Virch. Archiv. Bd. 60.

M.

165. Maclaren.—Pyæmia without wound. Glasgow Med. Journal, Aug. 1871.
*166. Magendie.—Journal de Physiologie, t. 3, s. 87.
167. Maissommuve.—Union Médicale. Nos. 119 and 120, 1869.
168. Manassein.—Zum Lehre v. Spirochaete. Petersburg Medic. Wochenschrift.
—— U. a. Beziehungs d. Bact., &c. C.-blatt. f. Med. Wiss., No. 12, s. 177, 1871.
169. Martin.—Recherches sur la Développement de Bact. Gazette Médicale d. Paris, No. 16.
170. Martini.—Beobachtungen u. Micrococen Embolien, &c. Archiv. für Klin. Chirurg., Bd. XVI., s. 157, 1873.
170a. Meissner.—Deutsche Zeitschrift f. Chirurgie, vol. XIII., by Rosenbach.
171. Mentzel.—U. d. Septisch. Eigenschaft d. frisch. Wundserum. Wien. Wochenschrift, No. 70, 1869.
*172. Meyer.—Journal f. Prakt. Chemie, Bd. 122, 1867, p. 124.
173. Miflet.—Beitrage z. Biologie d. Pflanzen. Bd. III., 1879.
174. Mignel.—Comptes Rendus, tom. 91, No. 1.
*175. Mikulicz.—U. d. Beziehung d. Glycerins z. Coccobacteria Sept. u. z. Septische Infect. Archiv. f. Klin. Chirurg., 1878, Bd. 22, p. 253.
176. Morris.—Pyæmia in Country. Med. Times and Gazette, March 1874.
177. Mott and Horsley.—J. Physiology, vol. III., No. 3.
178. Moxon and Goodhart.—Septicæmia. Guy's Hospital Reports, No. XX., p. 229, 1875.
179. Müller.—Experiment Studien. Munich, 1867.
*180. Muntz.—Compt. Rend., 1875, t. 80, p. 1250.
*181. Musculus.—Pflügers Archiv, Bd. XII., s. 214.

N.

182. Naegeli.—Munich, 1877, and numerous communications.
183. Nassiloff.—Virch. Archiv, Bd. L., p. 551.
184. Nedsvetzki.
185. Neelsen.—Beiträge z. Biologie d. Pflanzen. Bd. III., s. 187.
186. Nencki.—Journal f. Prakt. Chemie., Bd. XX., NF., p. 34, also, p. 339, 1879; *ib.* 1878, p. 105, c. *Schaffer*; *ib.* 1879, p. 443.
—— Beiträge z. Biologie d. Spaltzulze. Leipzig, 1880.

App. B. No. 4.

On "Septic Bacteria" and their Physiological Relations; by Mr. Horsley.

116. Hocum.—Bacteria in Urine. New York Med. Record, Sept. 22, 1877.
116*a*. Hoffmann.—Wien. Med. Wochenschrift, No. 13, 1873.
*117. Hoppe.-Seyler. Med. Chem. Untersuch. Tubingen. Heft 4.
—— „ Physiol. Chemie, Bd. 1, p. 116, 1877.
118. Horsley and Mott.—Journal of Physiology, vol. III., No. 3.
119. Horvarth.
120. Huber.—Deutsches Archiv f. Klin. Med., Bd. XXV., s. 240. (Massenkrangen.)
*121. Hüfner.—Journal fur Prakt. Chemie., B. 13, p. 475, 1876. Also, 1877, p. 43, p. 194. With Marchwort, ec. do. 1874, pp. 148, 385.
*122. Hüppe.—Chem. Centralbl. 1881, 745.
123. Hüter.—D. Allgemeine Chirurg. Leipzig, 1873.

I.

124. Ihlder.—Faülniss, Erscheinungen. C.-blatt f. Medicin Wissenschaft, No. 2.
124*a*. Israel.—U. s. n. Erfahungen a. d. Gebiete d. mykose, &c. Berlin, Klin. Wochensf., No. 49, 1878.
—— Neue Beobachtungen, a. a. Geb. d. mykose. Virch. Archiv, Bd. 74, p. 15.

J.

125. Jeannel.—Sur l'Infection purulent ou Pyohémie. Paris, 1880.
*126. Jeanneret.—Zersetzung v. Gelatin, &c. Journal f. Prakt. Chem., Bd. 123, 1877, p. 353.
127. Jessop.—An Outbreak of Septic Fever. Med. Times and Gaz., Sept. 1873.
*128. Joubert et Pasteur.—Compt. Rend., t. 85, p. 101, 1877.

K.

*129. Kaufmann.—U. d. Zersetzung d. Blutes d. Bacillus subtilis. Journal f. Prakt. Chemie, Bd. 125, 1878, p. 71.
*130. Kehrer.—U. d. putrid Gift. Arch. f. Exper. Pathol., Bd. 2, s. 33.
130*a*. Kettler.—Thèse. Dorpat.
131. Klein.—Reports to the Medical Officer of Privy Council and of Local Government Board.
—— Quarterly Journal of Microscopical Science, vol. XV., p. 381.
132. Klebs.—Die pyrogene Substanz. Centralblatt f. Med. Wissenschaft, No. 27, 1868.
—— Der Ursach. d. Infect. Virchow u. Hirsch. Jahresbericht, p. 227, 1871.
—— „ „ Archiv f. Experiment Pathol. Bd. 2, p. 350; Bd. 4, s. 207; Bd. 4, s. 409.
133. —— u. Tommassi.
134. Koch.—Beiträge z. Biologie d. Pflanzen. Aetiologie a. Wundkrankheiten. Leipzig, 1876.
—— Mittheilungen aus d. Kaiserlichen Gesundheitsamte. 1881. (Three communications on Pathogenous Organisms.)
—— D. Artiologie d. Tuberculose Beul. Klin. Wochenschr. 1882. No. 15.
135. Kocher.—Berne.
136. Koester.—Embolisches endocarditis. Virch. Archiv, Bd. 72, s. 257, 1878.
—— „ „ Dorpat, 1877.
137. Köhler.—Septic Infect. Virchow und Hirsch. Jahresbericht, 1877.
138. Kolaczek.
139. Koster.
140. Küssner.—Centralblatt f. Med. Wissenschaft, 1870, p. 498.

L.

141. Laborde. Septicaemie Experimentale. Gazette Médicale, No. 6, 1874.
*142. Lacassaigne.—De la Putridité morbide et septique. Montpellier, 1872.
143. Lancet.—Sept. 1872. Sept. 18, 1867. 11, 7, 1866.
—— No. 30, 1872.
—— June 8, 10, 24, 1871.
144. Landan.—Zum Aetiologie d. Wundkrankheitens. Archiv f. Klin. Chirurg. Bd. 17. Heft 4, s. 527, 1874.

145. Lankester.—Quarterly Journ. of Microscop. Science, vol. XIII., p. 408.
146. Leber.—Entzündung d. Hornhaut. C.blatt. f. Med. Wissensch., No. 9, 1873.
147. Lee.—Decomposition of Blood in Living Vessels. Med. Press, July 3, 1872.
*148. Lefort.—Mémoire sur Phosphates en Putrifaction. Bulletin de l'Acad., No. 8, 1874.
149. Lemaire.—Compt. Rend., t. LVII., p. 625.
—— „ „ t. LIX., p. 317.
150. Leplat (et Jaillard).—Compt. Rend., 1864, p. 250.
151. Letzerich.—Experiment. Untersuch. Virch. Archiv, Bd. LXVIII., s. 519.
—— Mycosis Oesophag. Archiv f. Exper. Pathol., Bd. VII., s. 223, 1877.
152. Leuret.
153. Levitsky.
*154. Lex.—U. fermentwirkung d. Bact. C.blatt., 1872, p. 291, 305, 513.
155. Lewis.—Organisms found in Blood of Man, &c. Calcutta, 1879.
156. Livon.—Inject d. bacteries d. l. sang sans effét. Gaz. Med., No. 33, 1877.
*157. Lister.—Quarterly Journal of Microscop. Science. Oct. 1873. Lancet, 1867, pp. 95, 353, 668.
—— Transactions R. S. Edinbro', v. XVII., 1875.
158. Loew u. Naegeli.—Journal f. Prakt. Chemic., 1880, p. 97.
159. Löffler.—Mittheilungen d. K. Gesundheitsamte. 1881, p. 134.
160. Lombroso.
160a. Longstaff.—Sanitary Record.
161. Lortet.—Les Végétaux parasites. Annales de Darmotologie, No. 1, p. 29.
162. Lostorfer.
163. Lüders.—U. Abstauung u. Entwick. d. Bact. termo. Archiv. f. Mik. Anat., Bd. 3. 1867.
164. Lukomsky.—Erysipelas. Virch. Archiv. Bd. 60.

M.

165. Maclaren.—Pyæmia without wound. Glasgow Med. Journal, Aug. 1871.
*166. Magendie.—Journal de Physiologie, t. 3, s. 87.
167. Maissommuve.—Union Médicale. Nos. 119 and 120, 1869.
168. Manassein.—Zum Lehre v. Spirochaete. Petersburg Medic. Wochenschrift.
—— U. a. Beziehungs d. Bact., &c. C.-blatt. f. Med. Wiss., No. 12, s. 177, 1871.
169. Martin.—Recherches sur la Développement de Bact. Gazette Médicale d. Paris, No. 16.
170. Martini.—Beobachtungen u. Micrococen Embolien, &c. Archiv. für Klin. Chirurg., Bd. XVI., s. 157, 1873.
170a. Meissner.—Deutsche Zeitschrift f. Chirurgie, vol. XIII., by Rosenbach.
171. Mentzel.—U. d. Septisch. Eigenschaft d. frisch. Wundserum. Wien. Wochenschrift, No. 70, 1869.
*172. Meyer.—Journal f. Prakt. Chemie, Bd. 122, 1867, p. 124.
173. Miflet.—Beitrage z. Biologie d. Pflanzen. Bd. III., 1879.
174. Mignel.—Comptes Rendus, tom. 91, No. 1.
*175. Mikulicz.—U. d. Beziehung d. Glycerins z. Coccobacteria Sept. u. z. Septische Infect. Archiv. f. Klin. Chirurg., 1878, Bd. 22, p. 253.
176. Morris.—Pyæmia in Country. Med. Times and Gazette, March 1874.
177. Mott and Horsley.—J. Physiology, vol. III., No. 3.
178. Moxon and Goodhart.—Septicæmia. Guy's Hospital Reports, No. XX., p. 229, 1875.
179. Müller.—Experiment Studien. Munich, 1867.
*180. Muntz.—Compt. Rend., 1875, t. 80, p. 1250.
*181. Musculus.—Pflügers Archiv, Bd. XII., s. 214.

N.

182. Naegeli.—Munich, 1877, and numerous communications.
183. Nassiloff.—Virch. Archiv, Bd. L., p. 551.
184. Nedsvetzki.
185. Neelsen.—Beiträge z. Biologie d. Pflanzen. Bd. III., s. 187.
186. Nencki.—Journal f. Prakt. Chemie., Bd. XX., NF., p. 34, also, p. 339, 1879; *ib.* 1878, p. 105, c. *Schaffer*; *ib.* 1879, p. 443.
—— Beiträge z. Biologie d. Spaltzulze. Leipzig, 1880.

App. B. No. 4.

On "Septic Bacteria," and their Physiological Relations: by Mr. Horsley.

T.

261. Terrillon.—Septicæmie. Arch. gen. de Med., Feb., 1874.
262. Testut.—Virchow u. Hirsch. Jahresbericht, 1873, p. 336.
263. Tiegel.—Archiv. f. Experiment Pathologie I., 1, 1873. Also, Virch. Archiv., Bd. 60, p. 453.
264. Tillmanns.—Verhandlungen d. Deutschen Ges. f. Chirurgie., 1878, s. 211.
265. Toussainy.—Charbon. Compt. Rendus, t. LXXXV., No. 23, 1877.
*266. Traube (m. Gschleiden).—Sitzungsberichte den Vaterländischen Gesellschaft. Med. Section, Feb. 13, 1874.
267. Tremblay.—D. eruptions a. operat et Septic. Gaz. Hebd., 1873, 35, 36.
268. Trousseau.
269. Tyndall.—Brit. Med. Journ., Jan. 27, 1877.

V.

270. Vacquerey.—Pyæmie. Thèse, 1875.
271. Vernueil.—Sur ictère traumat. Bulletin de l'Acad., No. 29, 1872.
—— Du pus impure, &c. Gaz. Hebd., Nos. 15, 16.
272. Virchow.—Archiv, Bd. 56, s. 415.
—— e. Stich.
273. Vogt.—Nachweis. C.-blatt. f. Med. Wiss., No. 44, 1872.
273a. Volkmann.—Sammlung. Bonn.
274. Vulpian.—Exp. sur la Septicæmie. Gaz. Hebd., 826, 1872.
—— Bulletin de l'Acad., p. 380, 1873.

W.

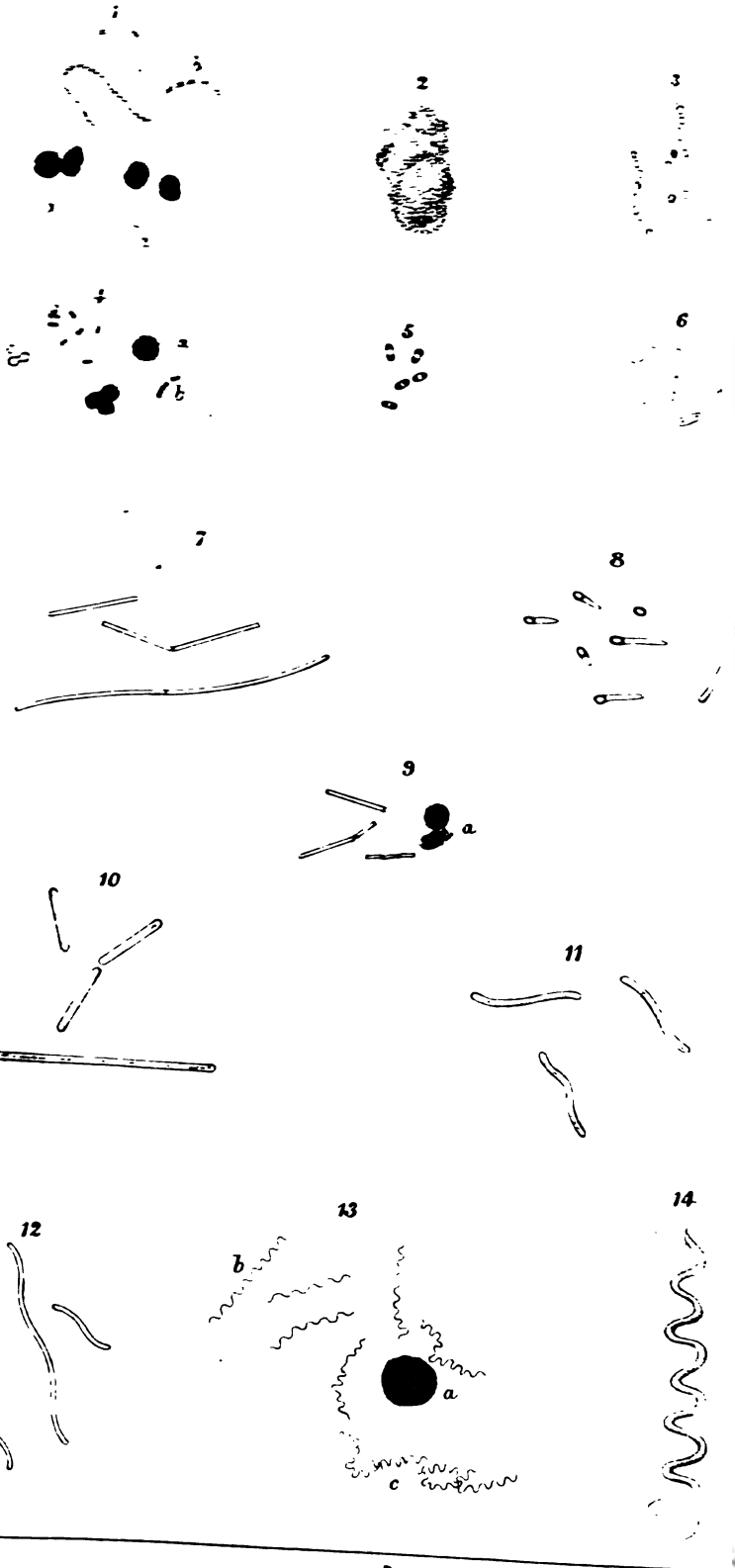
275. Wagstaffe.—Temperature in Pyæmia. Lancet, March 29, 1873.
*276. Wälchli.—U. d. Faülniss d. Elastin u. Mucin. Journal f. Prakt. Chemie., Bd. 125, 1878, p. 71.
277. Weber.—Deutsche Ælinik, 1864, 48–51.
—— 1865, 2–8.
*278. Weidenhain.—Expt. in Putrid Gift. Dorpat, 8, 66, 88.
279. Weigert.—Z. B. frage. Berlin Klin. Wochenschrift, Nos. 18, 19, 27, &c.
280. Weissgerben (u. Perls).—Archiv. f. Exp. Pathol., Bd. 6, p. 113.
281. Wells (Spencer).—Med. Times and Gazette, Jan. 27th, 1872.
282. Wernich.—Bertrage z. Biologie. a. Pflänzen, Bd. III., 1879. Also, Berlin. Klin. Wochenschrift, Nos. 4–5, 1880.
283. Wilke.—Pyæmia. Berlin Klin. Wochenschrift, No. 13, 1872.
284. Winge.—Virchow. Archiv, Bo. 56, s. 408.
*285. Wittstein.—V. J. Schrift, f. Prakt. Chemie., 1869, III. and IV.
286. Wolff.—C.-blatt f. Med. Wissenschaft, 173, p. 498.
—— Virch. Archiv., Bd. 81, s. 193.

Y.

287. York, New.—Prevent. of Pyæmia in Bellve. Hosp. New York Med. Record, Sept. 1, 1872.

Z.

288. Zahn.—Arbeiten a. d. Berner. Patholog. Institute, 1871.
—— „ „ „ 1872.
*289. Zalesky.—See Fayrer.
*290. Zuelger.—Stud. u. a. Putrid Intoxicat. Arch. f. Experiment. Pathol., Bd. VIII., s. 133–139.
—— Berich. a., Landwirthshaftlichen Institute, Leipzic, 1881.



sley delt

DANGERFIELD LITH 22. BEDFORD S' COVENT GARDEN

EXPLANATION OF FIGURES.

PLATE I.

Fig. 1. Micrococci in pus. (*a.*) Pus corpuscle. (*b.*) Chain of cocci simulating chain of bacterium termo.
„ 2. Zoogloea mass of micrococci
„ 3. Torula form of micrococcus ureæ (Cohn).
„ 4. Bacterium termo in pus. (*a.*) Pus corpuscle. (*b.*) Chain of bacterium termo. (*c.*) Diagram of actual outline of bacterium termo.
„ 5. Bacterium found in septicæmia of birds (Koch), probably identical with those of Davaine's septicæmia (Dowdeswell).
„ 6. Bacterium lineola (Cohn).
„ 7. Bacillus subtilis.
„ 8. Spore bacteria, or helobacteria of authors, perhaps transition forms in spore development.
„ 9. Bacillus anthracis. (*a.*) Leucocyte.
„ 10. Bacillus ulna (Cohn).
„ 11. Vibrio rugula.
„ 12. Vibrio serpens (Cohn).
„ 13. Spirillum tissue (*b*), and spirochæte (*c*), a red blood corpuscle (Koch).
„ 14. Spirillum volutans (Cohn).

PLATE II.

Fig. 15. Mechanical mycosis. Small vessels in omentum of guinea-pig plugged with bacillus anthracis. The nuclei belong partly to the capillaries (the walls of which are rendered almost perfectly transparent by the balsam), and partly to the serous epithelium and corpuscles of the serous membrane.

„ 16. Leucocytes containing rods.

The figures are original except where otherwise indicated.

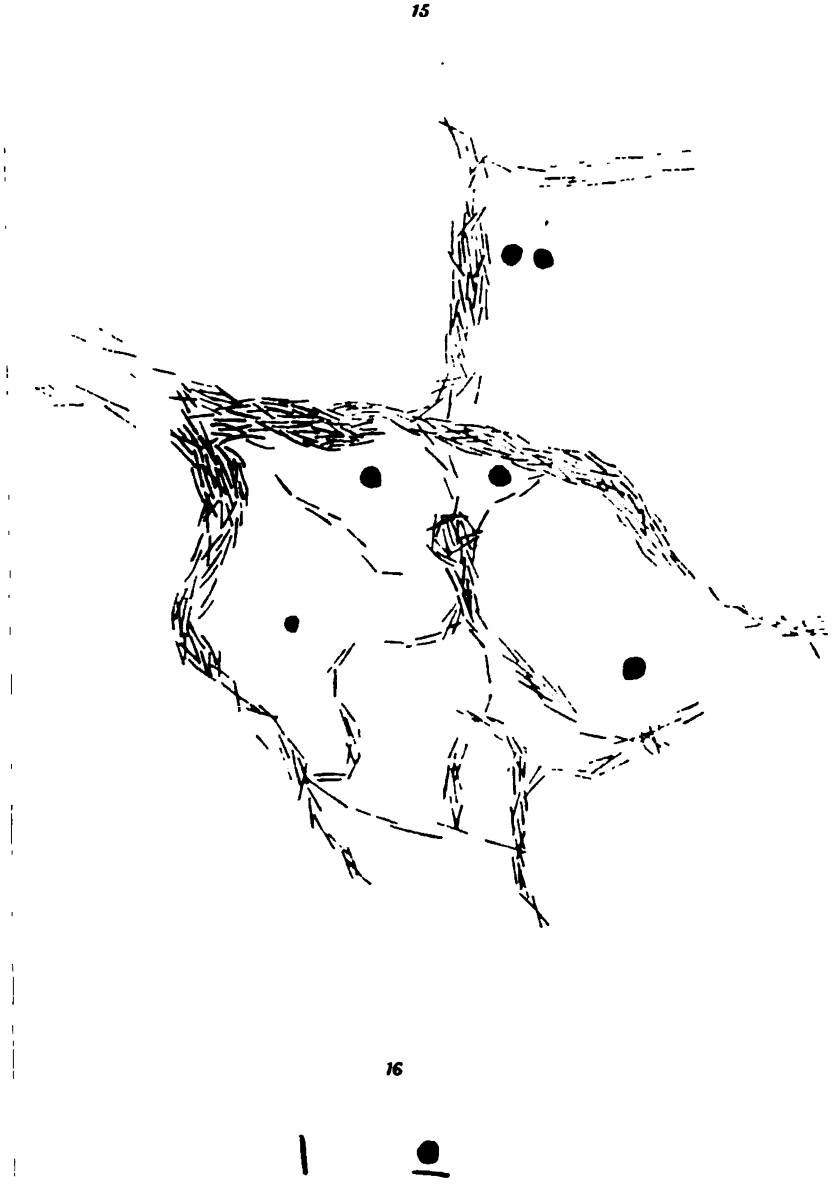
Figs. 3, 6, 10, 16, 12, 14, magnified under Hartnach, min. obj. IX., oc. III.

„ 5, 13, 8, „ „ 700 diameters.

„ 1, 2, 7, „ „ Hartnach, min. obj. X., oc. III.

„ 4, 9, 15, „ „ „ obj. XIII., oc. IV.

„ 16, „ „ „ „ „ increased twice.



4017

I. Horsley delt

Dangerfield. Lith 22. Bedford S.r Covent Garden

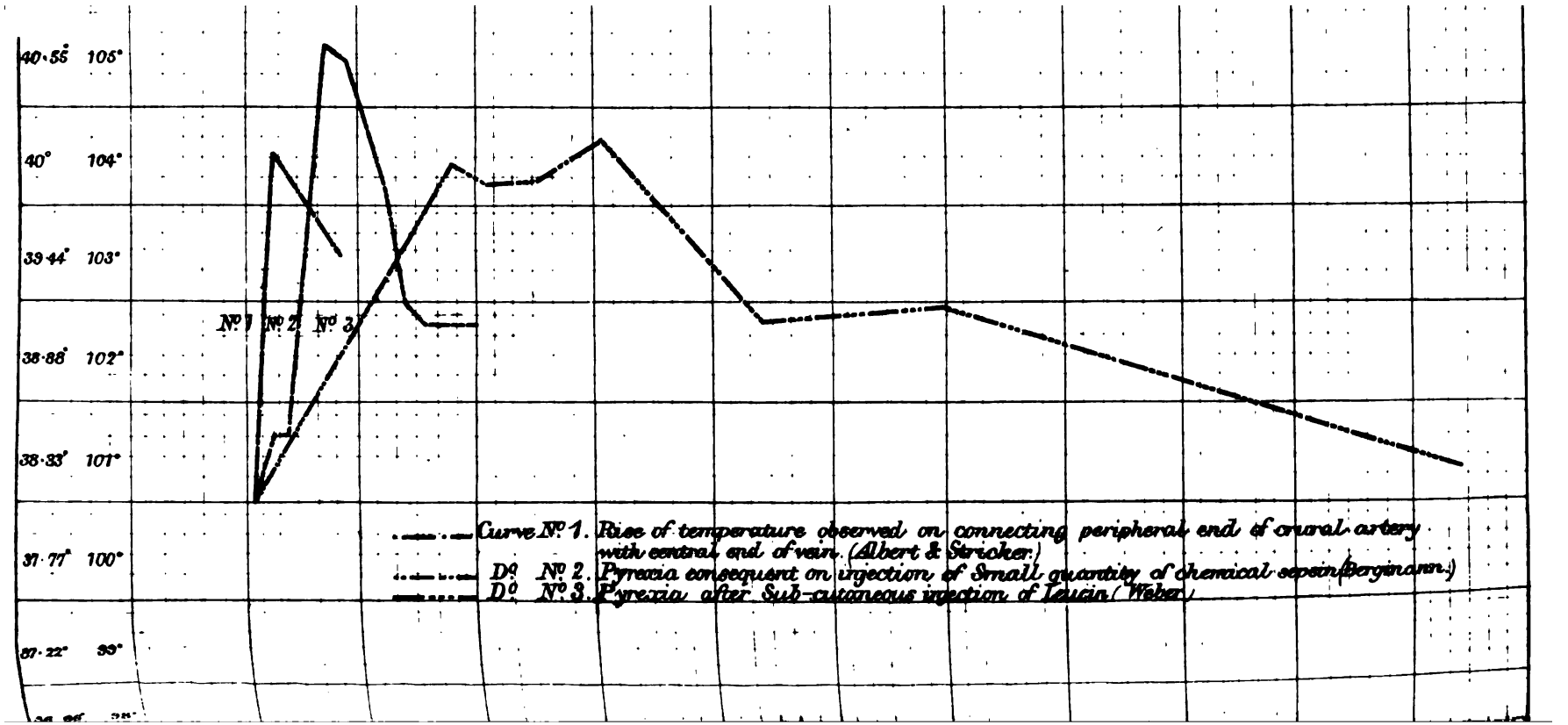
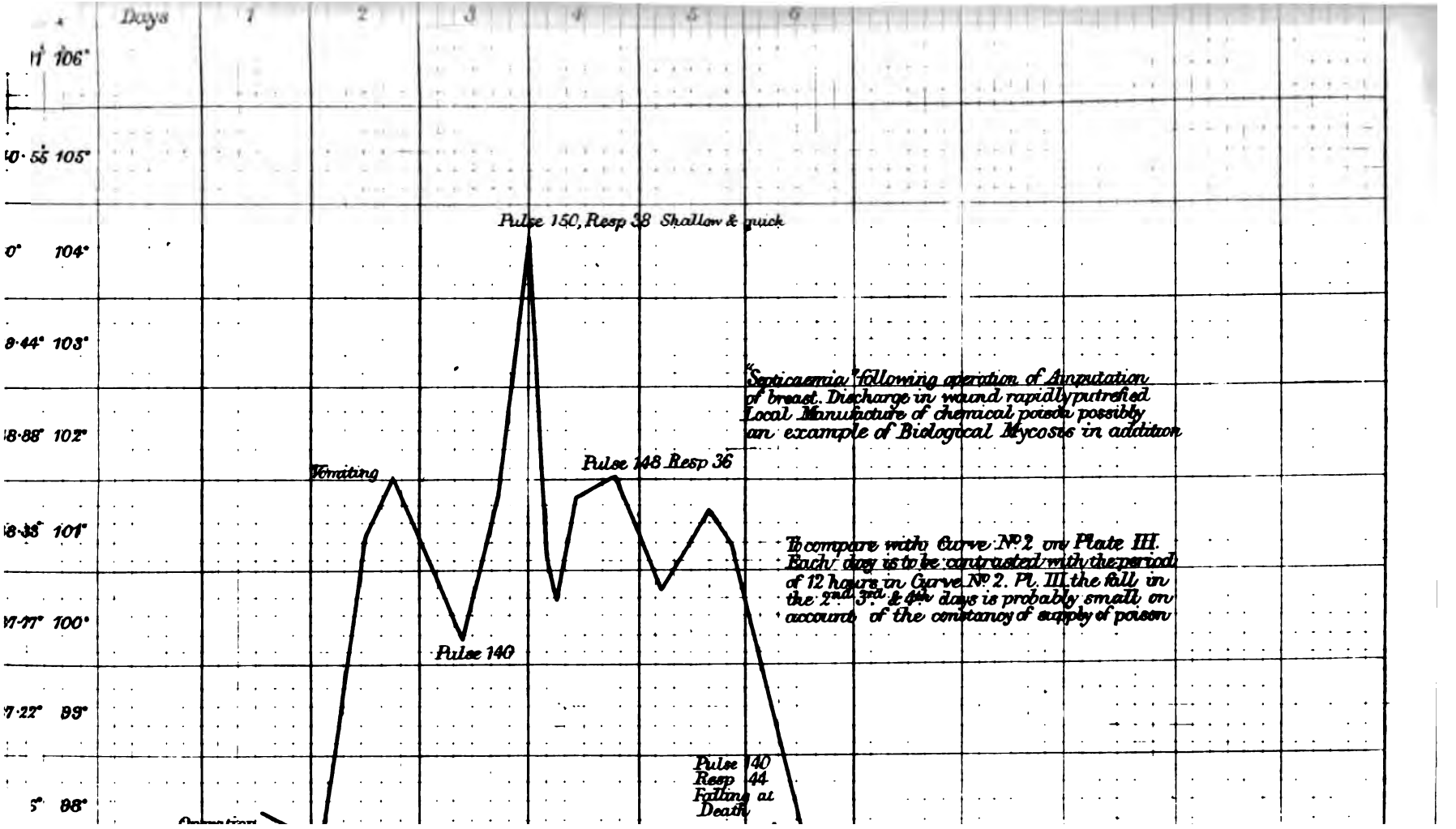

40·55° 105°
40° 104°
39·44° 103°
38·88° 102°
38·33° 101°
37·77° 100°
37·22° 99°
Nº 1 Nº 2 Nº 3
Curve Nº 1. Rise of temperature observed on connecting peripheral end of crural artery with central end of vein. (Albert & Stricker.)
Dº Nº 2. Pyrexia consequent on injection of small quantity of chemical sepsin (Bergmann.)
Dº Nº 3. Pyrexia after Sub-cutaneous injection of Leucin (Weber.)

PLATE III.

Curves to compare errors in the investigation of pyrexia introduced (1) by operation, (2) by accessory substances with the result of infecting the chemical poison. Curve (3).

PLATE IV.

Curve in septicæmia consequent on operation to compare with Plate III.


Days
1
2
3
4
5
6
106°
105°
104°
103°
102°
101°
100°
99°
98°
Pulse 150, Resp 38 Shallow & quick
"Septicaemia" following operation of Amputation of breast. Discharge in wound rapidly putrefied Local Manufacture of chemical poisons possibly an example of Biological Mycosis in addition
Vomiting
Pulse 148 Resp 36
To compare with Curve No 2 on Plate III. Each day is to be contrasted with the period of 12 hours in Curve No 2. Pl. III the fall in the 2nd 3rd & 4th days is probably small on account of the constancy of supply of poison
Pulse 140
Pulse 140
Resp 44
Falling at
Death

No. 5.

Further Researches on the Chemical Constitution of the Brain; by J. L. W. Thudichum, M.D., F.R.C.P.

CONTENTS

		Page
I.	On the presence in the brain of a group of non-albuminous organic immediate principles containing sulphur as an essential ingredient	287
II.	On the cerebrin substances which combine with metallic oxydes, sulphurised principles, sphero-cerebrin, and others	290
III.	On a new compound of cerebral inosite with cupric oxyde	294
IV.	On a new reaction and compound of cerebral tyrosin	297
V.	Chemolysis by baryta of albumin from brain	299
VI.	Properties of common tasteless leucin and of its copper compound, studied with a view of establishing its diagnosis from its isomer glycoleucin	302
VII.	On glycoleucin, the first chemical isomer of leucin, its properties and combinations	305
VIII.	On some new alkaloids obtained from brain-albumin by chemolysis	306
IX.	Quantation of the chemical constituents of grey and white tissue of the brain	309
X.	Quantation of the absolute and specific gravities of a human brain and of several parts	313
XI.	Systematic quantitative analysis of the brain	316
XII.	Quantation of the constituents of an entire human brain. With table of data	322

I.—On the Presence in the Brain of a Group of Non-Albuminous Organic Immediate Principles containing Sulphur as an essential Ingredient.

A sulphurised principle had already been discovered in the lead salt from ox-cerebrins, regarding which some preliminary information has been given in a previous chapter. I may also here anticipate the notice of an interesting observation to be related hereafter, namely, the deposition of metalloid *crystallised sulphur* from extracts of brains of young animals. I may also again refer to the finding by Couërbe* of sulphur in all the substances which he had isolated from the brain, a circumstance which fell under the criticism of Frémy and the French Academy, and was mainly instrumental in causing Couërbe's researches to be disbelieved and rejected. I have lately again expressly tested the phosphorised substances which I have isolated and named, and found that they do not contain sulphur as an essential constituent. A gramme of pure kephalin gave only an unweighable trace of barium sulphate; and so with myelin and lecithin. But when I came to the substance termed by Couërbe *stearoconote*, I found reason to think that in this particular the analysis of Couërbe had not been altogether incorrect, though it

* An abstract of Couërbe's publication on the Brain was given in Reports, New Series, No. III., 1874, p. 216, et seq.

may have been affected by the same fault as the others. But there is this difference between the finding of Couërbe and the data which I am going to describe: Couërbe's stearoconote was a substance educed without any other reagents than solvents. The sulphur-compounds to be described in the following were educed with the aid of baryta. They are very similar in bearing to stearoconote, and call for a careful comparison of the two.

The discovery of these sulphur compounds is only an incident in the researches on the ingredients of the (human) cerebrin mixture. Yet, owing to its importance, I have placed it as the title at the head of this chapter. It will, however, be seen that the processes employed have led to the isolation of other substances as well characterised as any hitherto described. But with regard to all of these I make the reservation which I have stated repeatedly in this report.

Human mixed Cerebrins. Baryta Process applied for their Separation.—I applied the baryta process in this case in the hope that, as others had by its means obtained cerebrin matter free from phosphorised matter, I might be equally successful. My experiment was, however, so far different from that of others, that I carefully avoided the possibility of the baryta acting chemolytically upon the cerebrin-substances. The baryta was therefore added only as long as it produced a precipitate, and never in excess, so as to be in solution in any appreciable quantity. I may at once state that in no single instance out of four experiments were the cerebrins obtained free from phosphorus.

The Process.—The preparations used were Nos. 3,396, 3,397, 3,398, and 3,399. The first three were 100 g. of human cerebrin mixture each, the fourth consisted of 300 g. of the same mixture. All four portions were treated by the same process, the only difference being that some received more, some less, baryta water, though they all received measured quantities. The cerebrin-substances were dissolved each 100 g. in 3 litres of hot alcohol. To the boiling solution baryta water saturated at the ordinary temperature was added in a thin stream, so as not to interrupt the boiling of the alcohol. The first 100 g. had 450 cc. baryta water added. The mixture was boiled for a few moments, and then the solution decanted from the adhesive *precipitate*. The latter became hard on cooling, and was detached and powdered. It was now exhausted with boiling alcohol; many extractions and pulverisations were required to withdraw all the matter which alcohol would re-dissolve.

Nature of the Precipitate produced by Baryta.—The baryta water does not produce a precipitate in the hot alcoholic solution of the cerebrin mixture by virtue of its water, as was specially proved by a blank experiment with water only. It precipitates, in the first place, *in combination with baryta*, a body (or mixture of bodies) which is soluble in cold benzol, and which will be treated of immediately. At the same time there fall down portions of the several cerebrin bodies, phrenosin, kerasin, &c., of which another portion remains in solution, and which are then again extracted from the precipitate by boiling alcohol without retaining more than traces of baryta, precipitable by carbonic acid from the alcoholic solution. These latter bodies are insoluble in cold benzol, and separable thereby from the stearoconote or mixture of baryta compounds.

It must at once be pointed out that the matters soluble in cold benzol cannot be separated from those insoluble in benzol by one operation

only. When benzol has acted upon the powdered particles of the precipitate, they seem to be covered by a layer of matter insoluble in benzol, which prevents this solvent from reaching the matters soluble in it, which are contained in the interior of the particles. It is therefore necessary to extract the powder alternately with cold benzol and hot alcohol, and sufficiently often until all the matter is dissolved in hot alcohol and cold benzol respectively, or remains insoluble in either.

Matters soluble in cold Benzol.—The benzol solution obtained in the manner described in the foregoing is clarified by repose, filtration, and decantation, until on standing further it remains perfectly clear and brilliant. It is then concentrated to a small bulk, with the precaution of keeping the solution perfectly liquid. It is now treated with absolute alcohol as long as a precipitate or turbidity is thereby produced. The precipitate is further extracted by boiling absolute alcohol, and dried in vacuo over oil of vitriol. (It constitutes No. 3,400 of the entire series of preparations, and its analysis will be fully described immediately.) The alcoholic mother-liquors, particularly those obtained by boiling, contain a quantity of a body which appears in curved needles, and therefore will be designated meanwhile as *curved needle body*. It constitutes Prep. No. 3,401 of the entire series.

Elementary Analyses of the Baryta-Compound soluble in cold Benzol and insoluble in Alcohol (Prep. No. 3,400).—It was dried over oil of vitriol, and at 70° in air-bath before analysis. Coloured powder.

(*a.*) *Quantation of Sulphur.* — 1·8542 g. were fused with flux and caustic, &c., and gave, on solution in nitric acid only, an insoluble precipitate, which was $BaSO_4$, and weighed 0·5398 g., equal to 4·0 °/₀ S in the compound.

(*b.*) *Quantation of Barium.*—To the acid filtrate from the foregoing sulphuric acid was added, and a second precipitate of $BaSO_4$ produced, which weighed 0·5734 g. Both quantations lead to a total of barium sulphate = 1·1132, equal to 35·30 °/₀ Ba in entire compound.

(*c.*) *Quantation of Phosphorous.*—The filtrate from the precipitate (*b.*) was made alkaline and treated with magnesia mixture, and gave pyrophosphate of Mg = 0·1693, equal to 2·55 °/₀ P in compound.

(*d.*) *Quantation of Carbon and Hydrogen by Lead-Chromate.*—·3292 gave 0·3725 CO_2, equal to 30·86 °/₀ C, and 0·1445 H_2O, equal 4·88 °/₀ H.

(*e.*) *Quantation of Nitrogen as Ammonia.*—0·5430 gave 0·0283 metallic Pt, equal to 0·74 °/₀ N.

Synopsis of Data:—

Elements.	Per Cents.	÷ by At.Ws.	÷ by S = 1(0·125).
C	30·86	2·5716	20·57
H	4·88	4·88	39·
N	0·74	0·0528	0·42
S	4·00	0·125	1·
Ba	35·30	0·257	2·
P	2·55	0·082	0·65
O	21·67	1·354	10·
	100·00		

The study of the relations of the atoms to each other gives at once some interesting information. The sulphur is to barium as 1 : 2, a fact which became already apparent in the course of the analysis. Carbon

and hydrogen are to each other as 1 : 2 very nearly, indicating the presence in the compound of radicles of the fatty series. Phosphorus and nitrogen stand apparently in no relation to each other, and in none to the sulphur or barium. The body is unquestionably a mixture, but may be of substances having some analogy with each other. At least the bearing of the product towards solvents would support such an hypothesis.

Several smaller preparations obtained in a manner similar to the process described in the foregoing were analysed, and gave, one, 32·97 °/₀ Ba, 1·06 °/₀ S, and 1·15 °/₀ P; the other, 22·14 °/₀ Ba, and 1·95 °/₀ S. They evidently contained a lesser proportion of the sulphurised body than the main preparation, and were, like that, preserved for future research.

II.—Sulphurised Principles, Sphero-cerebrin, and others. On the Cerebrin Substances which combine with Metallic Oxydes. From Ox Brain.

I now approach that part of the subject of brain research which seems to contain within itself, if not the greatest amount, at least the greatest number of difficulties. What I have to state should not be considered otherwise than as preliminary observations which may serve as the basis for future more perfect inquiries. Of some bodies the mere existence has been ascertained, and they have not been definitively isolated. Others have been isolated in a state of artificial combination with reagents. Two have been isolated in such a state of semi-crystallisation (sphero-crystals and groups of microscopic needles) that their appearance and behaviour gives some sort of probability to the assumption that they are approximately pure. But the only final control of actual composition, quantation of atoms and weight by combination and demonstration of constitution by chemolysis could not yet be applied to them. Indeed, all-important as I think the observation which I shall have to relate, I should not have published them in their present shape were I not under the obligation of reporting my researches.

Mode of separating these Substances from the Cerebrin Mixture.

The cerebrin mixture is, as we know, that part of the peculiar white matter of Vauquelin which remains insoluble when it is exhausted with ether. This cerebrin mixture is dissolved in hot spirit, and to the solution a hot solution in spirit of acetate of lead is added as long as a precipitate is produced. Ultimately a little ammonia is added, and the solution is filtered hot from the precipitate. The latter contains the bodies here to be considered.

The crude Lead Compound, to be hereafter referred to as "Dark Lead Salt, Ox-Cerebrins.

This body was exhausted with boiling spirit, the extraction being repeated an indefinite number of times; all that which spirit extracted will not be considered any further in this place. The matter insoluble in spirit was now extracted with benzol until nothing further dissolved. There remained insoluble a lead compound which had a peculiar ash-grey colour, reminding the observer at once of the probability that a small part of the lead had by some means or other been converted into sulphide.

Quantation of Lead and Organic Matter and of Sulphur and Phosphorus in the Dark Lead Salt.

(*a.*) 1·2992 g. decomposed with hydrothion in hot spirit gave 0·3490 Pb S, equal to 23·27 °/₀ Pb, and therefore about 76·73 °/₀ of organic matter.

(*b.*) 1·4826 g. burnt with soda and mercuric oxyde in a tube, &c., gave 0·1749 $BaSO_4$, equal to 1·62 °/₀ S, and 0·1574 pyrophosphate of magnesia, equal to 2·97 °/₀ P.

Attempt to isolate the sulphurised Principle, the Presence of which was demonstrated by the foregoing Analysis.

The alcoholic solution which had been obtained in analysis (*a.*) of the foregoing paragraph deposited much organic matter on cooling; this was redissolved by heat, and in the hot solution a precipitate was produced by baryta water. The precipitate was exhausted by boiling spirit, and the extracts were disregarded. The matter insoluble in spirit was dissolved in benzol, and the solution separated from the insoluble portion. The benzol solution was concentrated by distillation, and precipitated by absolute alcohol. The precipitated (stearoconote) body was dried and analysed.

0·3068 (being almost the entire product of this first operation) fused with nitre-flux, &c., gave 0·0288 $BaSO_4$ = 1·32 °/₀ S.

This experiment proves that the sulphurised principle contained in the lead salt can be transformed into a baryum salt soluble in benzol. This salt contained less sulphur than the original lead salt. When it is compared to other sulphurised baryum compounds of similar properties, which I shall have to describe below, it is seen that in the former the sulphur amounts to a much lesser percentage than in the latter. This is probably due to the fact that the lead salt has undergone many operations for the separation of its ingredients, whereas the compound with the larger amount of sulphur has undergone a lesser number of operations. From a third series of observations to be related, it will be seen that the brains of young animals contain at least one sulphur body, which is so labile that on standing in its ether solution it deposits *sulphur* in the metalloid state, and in crystals too, which are needles as well as octohedra. We have therefore three distinct aperçus proving the presence of sulphur compounds (other than albuminous ones) in the brain.

Decomposition of the Dark Lead Salt (Ox-Cerebrins) by Oxalic Acid in boiling Spirit.

It was evident that for the study of the sulphur compound in the lead salt the application of sulphuretted hydrogen, although apparently quite successful in the above experiment, would have to be avoided. A quantity of the salt was therefore boiled with double that amount of crystallised oxalic acid, which theory indicated as necessary for the transformation of all lead into oxalate, in a flask fixed to a refluent cooler, until the salt appeared white and all grey colour had disappeared. The solution was now filtered from the precipitate.

Insoluble Lead Salt (Oxalate).—It was exhausted with spirit, then washed with boiling water, suspended in water, and treated with dilute nitric acid. On heat being applied a reaction ensued, the oxalate dissolved, and a small quantity of lead sulphate remained insoluble. It weighed 0·0348 g. equal to 0·0037 g. S in 20 g. salt, or 0·0185 °/₀ S in lead salt. This shows that of the 1·62 °/₀ S contained in the lead

salt, only a minute proportion can be present as sulphuric acid, or in the shape of a metallic sulphate. Possibly even the small quantity found was derived from the oxydation of the black sulphide, which gives to the salt its dark colour.

The organic Matter from the Lead Salt (total mixture of at least three bodies) was crystallised from the spirit containing the excess of oxalic acid, washed and pressed. It was next recrystallised from spirit and appeared white and voluminous. It was analysed in order to ascertain whether it contained sulphur and phosphorus, with the following result.

(*a.*) 0·8668 fused with flux and caustic soda gave 0·0340 $BaSO_4$ = 0·54 % S.

(*b.*) The solution filtered from the $BaSO_4$ gave further 0·0638 pyrophosphate of Mg, equal to 2·06 % P.

The organic mixture was now extracted with cold benzol and filtered by air pressure through a tubular filter. The benzol extracted a small quantity of a body which was recrystallised from spirit, and crystallised in needles. The part insoluble in benzol was also recrystallised from spirit. It was then recrystallised from hot benzol and deposited entirely on cooling. After having been freed from benzol it was dissolved in about a litre of absolute alcohol, and cooled to 38°. A body was deposited in heavy *sphero-crystals*, and adhered to the glass, so that the solution could be easily decanted clear from it. This was repeated, and all crystals were collected. They represent the body which in the following is termed *sphero-cerebrin.*

Sphero-cerebrin.

The name is intended to indicate that the body is a cerebrin crystallising in sphero-crystals. It was twice crystallised fractionally from absolute alcohol. The solution having been filtered clear, was now allowed to cool while the temperature was read off by an immersed thermometer; it began to form a deposit at 50°, of which the main bulk came down between 43° and 41°. When the deposition had ceased, the sphero-cerebrin was filtered off.

Seen under the microscope it appears in round balls of very uniform size, which all have a peculiar three branched mark in the round field (*a*). When the balls are rolled it is seen that they contain three wedge-

a. *b.* *c.*

shaped fans each; the side of such a fan appears like (*b*), and shows radiating needles; three such wedges are united with their sharp straight edges at a line representing the diameter of the ball. By gentle pressure the balls break almost regularly into the three wedge-shaped segments.

Sphero-cerebrin, with oil of vitriol, on standing, gives only a very feeble reddish colour attached to flakes. It is free from sulphur, and contains only unweighable traces of phosphorus (when 0·4462 were analysed).

Analyses.—Dried at 95° (*a.*), 0·6390 g. burnt with lead chromate gave 1·4703 CO_2, = 62,75 % C, and 0·6362 H_2O = 11·08 % H.

(*b.*) 0·3842 burnt with soda lime, &c., gave 0·0337 metallic platinum equal to 1·23 °/₀ N.

(*c.*) A quantity which had been dried at 90°, when heated to 110° during five hours, lost nothing in weight.

Synopsis.

	Per cents.	Atoms.
C	62·75	58
H	11·08	123
N	1·23	1
O	24·94	17·3
	100·00	

In its main features sphero-cerebrin resembles to cerebrinic acid, but it contains over this (theory $C_{59}H_{115}NO_9$) an excess of 8 H and 8 O, or eight hydroxyls. Sphero-cerebrin differs, however, from cerebrinic acid by its crystalline shape, and by its per centic composition. (See Annals. II. 40.)

Principal and second Product from Dark Lead Salt.

The term principal here refers to quantity; 20 g. of lead salt gave 15·49 of organic product. This quantity was split up into the following separate quantities :—

Principal product (not yet unitary) - -	9·59 g.
Second product (more soluble than foregoing)	4·04 „
Sphero-cerebrin (least soluble in alcohol) -	1·50 „
Needle body soluble in benzol - - -	0·36 „

The absolute alcohol solution had been filtered at 40°. At 37° cumuli of clouds formed under the bulb of the thermometer. At 36° the entire liquid was turbid. At 35° all translucency was lost, and the crystals projected from margin into fluid. At 34° the surface became concave, and the marginal ring of deposit was out of the fluid. The particles aggregated and the fluid became again translucent. At 32° clouds of deposit sank, and the temperature remained stationary for some time. At this point the deposit was separated by filtration.

At 30° to 29° a new cloudiness arose, and a deposit began to adhere to the glass. This second deposit included almost all of the matter which was in solution in the alcohol. These processes, therefore, resulted in the separation of the organic matter present in the lead compound in the greatest quantity into two bodies, one of which, *the least soluble in alcohol*, was recrystallised by itself, while the other, *the most soluble in absolute alcohol*, was also recrystallised by itself.

We have, therefore, at this stage the organic matter in the lead salt separated into the following five products, arranged in the order of decreasing quantities :—

(1.) Principal product - - -	9·59 g.
(2.) Second product (more soluble than foregoing)	4·04 „
(3.) Sphero-cerebrin - - -	1·50 „
(4.) Body soluble in benzol - - -	0·36 „
(5.) Sulphurised compound - - -	—

Analysis of the principal product from Dark Lead Salt (Ox-Cerebrins).

(1.) Water expelled at 90°. 1·6225 g. air dry, lost 0·0564, equal to 3·4800 °/₀ H_2O.

(2.) Phosphorus quantation in anhydrous substance. 0·4353 gave 0·0074 Mg pyrophosphate = 0·3700 °/₀ P.

(3.) Carbon and hydrogen 0·7631 gave (burnt with chromate and copper oxyde) 1·6586 CO_2 = 59·28 % C, and 0·7474 H_2O = 10·09 % H.

(4.) Quantation of nitrogen as NH_3. 0·5284 gave 0·1108 platinic chloride salt = 1·32 % N. The Pt. in the salt weighed 0·0485 = 1·30 % N.

It is at once evident that this body is a mixture of a phosphorised principle with at least one cerebrin-like body. If we assume all the phosphorus to be present in the shape of one molecle of dineurostearyl-phosphoneuryl-glyceride ($C_{44}H_{83}NPO_8$), and deduct this molecle from the complex of molecles obtained as an empirical formula with P = 1, then we obtain a residue with more than seven atoms of nitrogen, which divided by N = 1 (*i.e.* by 7·36) give a formula not unlike a cerebrin-body with three nuclei of neurostearic acid, but with a quantity of oxygen, which is too large to satisfy that hypothesis simply.

Synopsis of the Percentages found and the Hypotheses applied.

	Per cents.	÷ At Ws.	÷ P = 1	Residue $C_{44}H_{83}NPO_8$ deducted.	÷ N = 1
C	59·28	4·94	449	405	55·02
H	10·09	10·09	917	843	113·3
N	1·30	0·092	8·36	7·36	1
P	0·37	0·011	1	0	0
O	28·96	1·81	164	156	21
	100·00				

We have, therefore, in the cerebrin residue of this mixture a still larger number of atoms of oxygen than in sphero-cerebrin. And this fact may ultimately lead to an explanation of the *acid* character of these compounds, which enables them to form firm compounds with bases, such as the cerebrosites of the phrenosin type do apparently not form.

The second more soluble is absolute alcohol product (weighing 4·04 g., see the list above given) has not yet been analysed. It is not known whether it is, or contains the sulphurised principle, the existence of which in the mixture has been proved above. This inquiry must be left to the future.

III.—On a new Compound of Cerebral Inosite with Cupric Oxyde.

It was natural that inosite, a sugar of the composition expressed by the formula $C_6H_{12}O_6$, should be tested regarding its bearing with copper salts. It was found that its watery solution, when added to one of potassio-cupric tartrate, deepened the blue colour of the latter; on the application of heat the colour changed to green, and a green deposit separated, after the removal of which the colour of the solution became again blue (Cloetta). The change of the colour of the solution from blue to green during the application of heat, and from green back to blue during the process of cooling, as well as the formation of the green precipitate, was attributed by Vohl to the presence with the inosite of foreign substances. Scherer, on the other hand, found that a mixture of solutions of inosite and cupric sulphate, yielded on addition of caustic potash-ley, a bluish green precipitate, which quickly disappeared on addition of excess of caustic-ley. When the solution was boiled no cuprous oxyde separated, but a light blue precipitate fell when the

mixture was allowed to stand some days. These data are at least in part contradictory, and as regards the production of a compound indefinite, none having been isolated or analysed. I resumed the study of these relations for the purpose of comparing the bearing of inosite towards copper salts, with that of the other eductes or chemolytic products of the brain. The following results were obtained in the course of this study.

When to a hot solution of inosite (from ox-brain) a saturated solution of copper acetate is added, a light green precipitate immediately ensues. When copper acetate is added in excess, so that the filtrate has a blue colour, and the mixture is warmed, almost all inosite is precipitated out of the solution. The green precipitate of inosite copper can be heated with pure water, without more than traces of copper dissolving in the water The solution is colourless, but gives a brown coloration with potassium ferrocyanide and acetic acid. The light green precipitate of inosite copper (*first precipitate*) on being dried in the air-bath at 110°, became dark green, nearly black, and was then analysed.

(1.) 0·0968 g. after ignition left 0·0568 g. CuO, equal to 46·84 °/₀ Cu.
(2.) 0·106 g. left 0·0629 g. CuO = 47·38 °/₀ Cu.

A compound of one molecle of inosite with three molecles of cupric oxyde, $C_6H_{12}O_6 + 3\ CuO$, of which the atomic weight would be $182 + 238·2 = 420·2$, requires 45·2 °/₀.

The compound when *boiled* with water is decomposed at the place where the vessel, whether platinum or glass, is hottest. It is not decomposed when warmed gently on the water-bath. When inosite is *evaporated* with excess of copper acetate on the water-bath, all inosite becomes insoluble in the shape of the compound described in the foregoing. The excess of acetate may be washed out with warm water, but the precipitate may not be boiled in platinum or glass over the free flame, as it forms a reddish brown adherent decomposition product. The compound is soluble in acetic acid, with slight coloration, without residue. It is soluble in ammonia, with a deep blue colour. A trace of matter remains insoluble (which is not the case with the acetic acid) and may explain the slight excess of copper found in the analyses.

When this compound was heated on platinum, it showed the following remarkable bearing: it scintillated and deflagrated, while evolving acid fumes. A red residue was left, which on being thrown into the air took fire and burnt (pyrophorus). Probably the three molecles of cupric oxyde gave up half their oxygen, and remained as cuprous oxyde mixed with some carbonaceous matter.

Second Precipitate.—On addition of more copper acetate to the solution from which the first precipitate had been filtered, and application of a gentle heat, a second precipitate ensued, which was and remained green. Dried at 110° it gave on analysis the following data:—

(1.) 0·2168 gave 0·1208 CuO = 44·50 °/₀ Cu.
(2.) 0·2719 „ 0·1537 „ = 45·12 „
(3.) 0·2550 „ 0·1410 „ = 44·15 „

When this compound in the state of powder was heated at the margin, it took fire, and then burned spontaneously through, leaving a red residue. This residue also was pyrophorous when thrown into the air.

Third Precipitate.—The mother-liquor of the second precipitate was concentrated by evaporation, and formed a third precipitate. This, after isolation, was dissolved in dilute ammonia, and reprecipitated by gentle evaporation. It was light green, and when gently dried was analysed.

(1.) 0·1293 g. gave 0·0631 CuO = 38·96 °/₀ Cu.
(2.) 0·1088 g. „ 0·0547 „ = 40·10 „

A trihydrate of the cupric inosite requires 40·10 °/₀ of Cu. That this compound, $C_6H_{12}O_6 + 3\,CuO + 3\,H_2O$ (atom. weight = 471·2) had really been obtained, was further proved by the loss which it suffered on being dried at 110°, being equal to three molecles of water. For the dry compound gave on analysis the following result:

(3.) 0·1001 g. gave 0·0579 CuO = 45·38 °/₀ Cu.

Fourth Precipitate.—This was obtained after the third, by the same process as the latter. It was bright green, and dried at 110° gave on analysis:

(1.) 0·0699 g. gave 0·04 CuO = 45·68 °/₀ Cu.

The Inosite from Ox-brain used in the foregoing research was a finely crystallised, on the whole very pure specimen. Nevertheless, the first precipitate was somewhat impure, as indicated by its physical properties and its composition. But the precipitate Nos. 3, 4 were so pure that their analyses yielded almost theoretical results.

It was therefore very surprising that an equally well crystallised and apparently perfectly pure specimen of *inosite from human brain*, on being mixed and treated with copper acetate like the inosite from ox-brain, should yield totally different and greatly varying results.

First Precipitate.—(Prep. No. 3069.)

(1.) 0·5149, dried in vacuo over sulphuric acid, lost at 110° 0·0[illegible] in weight, corresponding to a loss of 1·53 °/₀ H_2O.

(2.) 0·6412, dried at 110°, gave 0·3813 CuO = 47·48 °/₀ Cu.

Second Precipitate.—(Prep. No. 3070.)

(1.) 0·3445, dried in vacuo, &c., lost at 110° 0·0061, corresponding to 1·77 °/₀ H_2O.

(2.) 0·4732, dried at 110°, gave 0·3036 CuO = 51·23 °/₀ Cu.

Third Precipitate.—(Prep. No. 3071.)

The mixture on further evaporation, formed only an insignificant precipitate, although after addition of copper solution it formed a fifth and a sixth precipitate, which contained more copper than the first precipitate. The third precipitate gave on analysis:

(1.) 0·2944, dried in vacuo over sulphuric acid, lost at 110° 0·008[illegible] = 2·85 °/₀ H_2O.

(2.) 0·3075, dried at 110°, gave 0·1837 CuO = 47·73 °/₀ Cu.

Fifth and Sixth Precipitate.—(Prep. No. 3072). Analyses:

(1.) 0·3807, dried in vacuo over sulphuric acid, lost at 110° 0·005[illegible] = 1·34 °/₀ H_2O.

(2.) 0·3429, dried at 110°, gave 0·2139 CuO = 49·81 °/₀ Cu.

These precipitates, therefore, contained about two, or four, or six per cent. more copper than corresponds to tri-cupric inosite. When they were dissolved in ammonia and the solution evaporated cautiously, discoloured products were obtained. From these data I conclude that the inosite from the human brain is either altogether different from that contained in the brain of the ox, or is accompanied by another similar carbohydrate of less stable quality. In any case, the subject calls for further investigation.

Inosite is a hexadynamic alcohol, and forms two nitrate ethers, a hexanitrate and a trinitrate. Similarly, though probably not by substitution of hydrogen, it forms a tricupric compound; and perhaps at the same time a small quantity of a hexacupric one, if the compounds with more than 45·2 °/₀ Cu have not to be considered as combinations with bodies other than inosite.

IV.—On a new Reaction and Compound of Cerebral Tyrosin.

In a former research I have shown that tyrosin is present amongst the amidated bodies extracted from the brain, though in small quantities only. It is also a product of the chemolysis of brain albumin, and as I have shown in another part of the present research, it cannot be separated so completely from the amido mixture as is desirable, and as is generally believed. To improve the processes of this separation I have made some experiments, which have resulted in the following. The experiments were made on Prep. No. 3002, being tyrosin from brain albumin.

Tyrosin dissolved in hot water with the aid of caustic soda ley, on addition of mercuric chloride, gives a deep yellow solution, and no precipitate. On cooling the mixture becomes turbid, and on reheating a yellow precipitate ensues. (Prep. No. 3020.) The solution of tyrosin must be *dilute, hot,* must contain excess of caustic ley, and the mercuric chloride must not be added in excess; if excess be added, a yellow precipitate is immediately produced. If to the dilute, hot, alkaline solution of tyrosin mercuric chloride is added gradually, until a faint yellow precipitate is produced, and the solution is heated and allowed to stand, the slight precipitate which forms on heating crystallises entirely in golden brown crystals, and is Hg_2OCl_2. The yellow amorphous precipitate, which forms out of the yellow solution on application of heat, is entirely soluble in excess of caustic soda. On heating the solution to boiling, no immediate precipitate is now produced. If the heating and addition of mercuric chloride are done very gradually near the boiling point, until the yellow fluid becomes opaque, it sets on cooling into a white solid jelly. This compound is dissolved in excess of caustic soda, the solution is filtered, and the compound is then reprecipitated with acetic acid. It is then perfectly white. The compound is therefore insoluble in weak soda, soluble in great excess of soda, and insoluble in dilute acetic acid. Dried over oil of vitriol in vacuo and analysed, the compound gave the following data:

Analyses.—(*a.*) 0·4463 g burnt with CuO, &c., gave 0·0716 H_2O=1·78 % H, and 0·2986 CO_2=18·25 % C; further 0·2739 g Hg=61·37 % Hg.

(*b.*) 0·3435 burnt with CuO, gave 0·2093 g Hg.=60·93 % Hg.

(*c.*) 0·5339 g fused with nitre flux, gave 0·1403 g. AgCl=6·50 % Cl.

(*d.*) 0·5233 g gave 0·1365 AgCl = 6·45 % Cl.

(*e.*) 0·7691 g by soda-lime process, gave ammonio-platinic chloride = 0·2922 at 130° = 0·1310 Pt=2·42 % N. (Calculation from the double chloride leads to 2·38 % N.) The same analysis gave 0·682 Hg = 60·88 %.

Synopsis of Data and Theory.

	Found %.	÷ by At. W.	÷N=1.	Hypothetical formula.	
C	18·25	1·520	8·7	C_9	
H	1·78	1·780	10·3	H_{10}	
N	2·42	0·1728	1·	N	×2+HgO.
Hg	61·37	0·3069	1·77	Hg	
Cl	6·48	0·1825	1·	Cl	
O	9·70	0·6062	3·4	O_3	
	100·00				

or 2 ($C_9H_{10}NO_3$ + Hg Cl) + HgO, or expanded in the following formula:

$$\left.\begin{array}{l} Hg-Cl \\ | \\ C_9\ H_{10}\ N\ O_3 \\ | \\ C_9\ H_{10}\ N\ O_3 \\ | \\ Hg-Cl \end{array}\right\} HgO.$$

It will thus be seen that the reaction essentially consists in a reduction of mercuric to mercurous chloride, which remains combined with tyrosin; and of this compound two molecles are soldered together by molecle of mecuric oxyde. It is not intended to fix the exact manner in which, and place (in the molecle) at which this union is effected. The reduction of the mercuric to mercurous chloride is no doubt effected by that part of the hydrogen of the tyrosin which does not appear in the precipitate; in other words, an atom of hydrogen is substituted by calomel. For this latter substitution the ordinary didynamic character of mercury affords an easy opportunity, but for the soldering action of mercuric oxyde the metal may hypothetically be allowed to possess a greater number of dynamicities than two.

Mercuric chloride is a general reagent for bodies of the alkaloid class. In this capacity it produces precipitates in almost all animal fluids, which contain albuminous matters or their derivates down to ammonia. The composition of these precipitates is as yet little studied, but is complicated enough to have deterred inquirers from ascertaining it. I have examined some such precipitates, *e.g.*, from the extract of the liver in kidney diseases. In such the reduction of mercuric to mercurous chloride is effected massively, but only a part of the calomel produced remains in combination. The foregoing research is a key to the study of such combinations.

Reaction of Tyrosin with Copper Acetate.

Two g of crystallised tyrosin were dissolved in boiling water, filtered hot and treated whilst boiling, with copper acetate. At first the fluid assumed a dark blue colour without forming any precipitate; on evaporation the liquid became green, and a quantity of black cupric oxyde was thrown down. When this was filtered off, and the evaporation was continued, a very small quantity of oxyde was again precipitated. This was once more filtered off, and the fluid further evaporated. The cupric oxyde was proved by combustion to contain no organic matter. It weighed about 0·8 g, being in proportion to the tyrosin taken as 1 : the atomic weights of both bodies are as $\frac{4}{11\cdot4}$. The mixture of tyrosin and cupric acetate solution, from which two precipitates of cupric oxyde had been removed by filtration, on being further evaporated, deposited more oxyde, but the sides of the vessel were covered by a very thin layer of metallic copper, while an acid vapour was being given off by the mixture. After great concentration crystals began to form, one variety being dark green, evidently, and as was proved, consisting of copper acetate, another variety being sky-blue, and little soluble in alcohol, were separated by lævigation with this agent. They contain a product of decomposition of the tyrosin, but the yield represents only a very small proportion of the tyrosin originally employed. The greater part of the tyrosin is evidently destroyed by the copper in a manner as to become volatile and disappearing during evaporation in the shape of volatile acid. If, as is probable, a copper compound can be formed with tyrosin, its production requires special precautions, which are as yet not ascertained.

V.—Chemolysis by Baryta of Albumin from Brain.

Further Researches on the Chemical Constitution of the Brain; by Dr. Thudichum.

The albuminous matter was obtained in a manner which has already been described in detail, namely, by exhausting brain (human or ox) with spirit of 85 °/₀ strength.

An amount of albumen, about 100 g. in weight, with six times its weight of crystallised baryta and four times its weight of water, part of the water being used to soak the albumen for some time previous to the admixture of the baryta was taken for the chemolysis.

The apparatus employed was an autoclave made expressly for the purpose of wrought-iron, and holding above five litres. The cover was airtight and secured by a screw clamp, while an adjustable valve provided for the escape of gas in case of the pressure rising beyond certain limits. The mixture above described was placed in the chemolyser, and the temperature raised to 180° C. by means of a rose gas-burner placed underneath. The heat was maintained at this height for six hours, whereupon the chemolyser was allowed to cool. When the autoclave was opened its contents emitted a strong smell due to ammonia, compound ammonias, albuminol, and other products of decomposition.

The semi-solid mass was extracted, placed in a platinum-still with much water and subjected to distillation. Two litres of distillate were drawn off, containing ammonia and compound ammonias in solution and albuminol in small white flakes; the latter were removed by extraction with ether.

Albuminal and sulphurised body.

The ether solution on evaporation left a small residue consisting of *albuminol*, mixed with a peculiarly smelling probably *sulphurised body*; the latter was gradually volatilised on standing, leaving the albuminol, which crystallised.

Watery distillate.

The watery distillate was neutralised with hydrochloric acid, and evaporated to dryness, and the mixture of salts was further treated for the separation of compound ammonias from simple ammonia, as will be described below.

Fixed baryta-mixture.

The mixture from which the volatile alkalies had been distilled was filtered, and the insoluble matter isolated.

Fatty acid, oxalic, phosphoric, and sulphurous acid.

This insoluble matter was treated with water, ether, and hydrochloric acid. A small quantity of a fatty acid went into solution in the ether, baryta with phosphoric and oxalic acid dissolved in the acid water, while barium sulphite remained insoluble.

Soluble matters.

The soluble matters filtered from the foregoing precipitate were freed from excess of caustic baryta by crystallisation. From the filtrate all baryta was removed by excess of sulphuric acid, and from the solution all acetic acid was expelled by distillation.

Acetic acid.

Alkaloids.

From the cold acid liquid *alkaloids* were removed by the addition of phospho-wolframic acid as long as a precipitate was produced. This precipitate was washed with water containing 5 °/₀ of sulphuric acid, and then decomposed with baryta as has been described. The solution containing the mixture of alkaloids was further treated as will be described below.

Mixture of amido-acids.

The acid filtrate from the phospho-wolframates, containing *the amido-acids* was freed from phospho-wolframic and sulphuric acid by baryta, and evaporated slowly to crystallisation. It deposited first tyrosin, then a mixture of leucin and tyrosin, then leucin and small quantities of other amido-acids. Then a syrupy mass remained, which contained yet some alkaloids besides amido-acids. Then *alkaloids* were as far as possible removed by a repetition of the phospho-wolframic acid precipitation just described. From the liquid more leucin was obtained. At last there remained a small quantity of *uncrystallisable matter* which was treated as follows:—

Tyrosin and leucin and other amido-acids.

Alkaloids, second part.

Further Researches on the Chemical Constitution of the Brain; by Dr. Thudichum.

Uncrystallisable matter.

Organic body from mercury precipitate.

Mother-liquor of mercury precipitate.

Separation of tyrosin and leucin.

Purification of tyrosin.

Purification of leucin.

Other amido-acids.

It was precipitated by mercuric nitrate and sodium carbonate. The *bulky precipitate* was washed with water by decantation, &c., and decomposed by hydrothion. The solution on evaporation left a colourless gummy mass of the same character as the original matter. It will be further treated of below. The *mother-liquor* of the mercury precipitate was also freed from mercury and found to contain but little organic matter.

The *mixtures of tyrosin and leucin* were united and warmed with water containing 10 °/₀ of absolute alcohol. This dissolved leucin and left tyrosin undissolved. The limits of accuracy of this process will be indicated lower down.

Tyrosin was purified by solution in hydrochloric acid, treatment with animal charcoal, and precipitation by sodium acetate; the precipitated tyrosin was crystallised from ammonia.

Leucin was purified by combination with copper, its solution being mixed and heated with copper acetate in a manner the details of which will be described below.

The copper-compounds of the leucins are almost insoluble in cold water, more soluble in boiling water. The copper-compounds of other amido-acids which accompany the leucins seem all to be more soluble in cold water, particularly those of lower atomic weights than leucin.

Glutaminic and asparaginic acid, which have been obtained by chemolysis from other albuminous substances, have not yet been isolated from the products of chemolysis of brain-albumen. It remains to be seen whether the compound alkaloids which have been observed will on long-continued chemolysis yield these acids. At present it seems as if the baryta process applied to brain-albumin did not produce them. It is, however, not impossible that they may be formed by the hydrochloric acid and tin process, which evolves them easily from casein.

Nitrogen as Ammonia from Brain-Albumin.—Baryta-chemolysis of of 10 g, and distillation gave volatile alkali, which was neutralised by hydrochloric acid and combined with platinic chloride. The dry salt was re-dissolved, and left 0·0550 g. insoluble matter, while the soluble double salt of ammonio-platinic chloride amounted to 2·8760 g. This corresponds to 0·1803 g., or 1·803 °/₀ N. The insoluble platinum salt contained 0·0077 g. N. This quantity of nitrogen is far below that obtained by the same process from other albuminous matters (cf. Ann. Chem. Med., 1, 23). It approaches that obtained from gelatin, namely, 2·55 °/₀. With regard, however, to this question the observations should be borne in mind which will be found on p. 24 of the Annals just quoted, to the effect that the nitrogen evolved as ammonia by albuminous substances rises with the quantity of the reagent, the time of its action, and the temperature at which it acts. In any case it is less than one-fourth of the total quantity of nitrogen contained in the albuminous substance.

Total of insoluble Barium Salts obtained from 10 g. Albumen.

These salts dry at 110° weighed 4·1760 g and, on analysis, were found to have the following constituents:—

Barium sulphate	0·083
Barium	2·425
Phosphoric acid (PO_4)	0·099
Oxalic acid	0·043
Sulphurous acid	0·008
Hydrothion	trace
Carbonic acid and soluble organic matter	1·246
Organic insoluble matter	0·272
Total	4·176

While in the foregoing experiment about 1 % of phosphoric acid was obtained, in another one the molybdate of ammonia process, &c. gave as much as 3·465 % phosphoric acid (PO_4). It is doubtful whether in this latter case all the phosphorised matters had been removed from the albumen. It is, however, evident that many analyses will be required before any average can be stated for this particular datum.

Barium retained by Amido-Alkaloid-Acid Mixture.—The mixture of amido-acids, alkaloids, and acids from which all excess of caustic baryta has been removed by carbonic acid, retains a considerable amount of barium in solution; this has to be removed previous to the distillation of the volatile acids. The amido-mixture from 10 g of albumin yielded 1·7830 g barium sulphate, equal to 1·0480 g Ba, or 10·48 %. This is only about half the quantity of barium retained in the chemolytic products of other albuminous substances, ossein excepted, in the products of which the barium retained amounts to 13·2 % (cf. Ann. Chem. Med., 1, 28).

Quantation of Acetic Acid from Brain-Albumen.—The acid distillate from 10 g of brain-albumen chemolysed as above described yielded 0·1586 g barium salt ($BaC_4H_6O_4$, At.W. = 255) equal to 0·074 acetic acid, or 0·74 %. This is only one-fourth of the quantity yielded by pure albumin, and only half that yielded by ossein or ichthyocollin (cf. Ann. Chem. Med., 1, 29).

Quantation of Tyrosin from Brain-Albumen.—The tyrosin, obtained by the chemolysis of 10 g of substance, was separated by alcohol, recrystallised from ammonia, and dried at 105°. It weighed 0·122 g. = 1·22 %. This is the smallest percentage of tyrosin as yet obtained from any albuminous substance by this process (cf. Ann. Chem. Med., 1, 31). I have stated in another part of this research how tyrosin is retained by the amido-mixture, and even by crystallised leucin. The quantities of tyrosin actually isolated must therefore be considered as minima until absolutely reliable methods for its isolation may have been found out.

Leucins from 100 g of Ox-Brain Albumen.—They were combined with copper by solution in boiling water and addition of excess of copper acetate. On boiling, a precipitate ensued, which was filtered off and washed with cold water until the washings were no longer blue. This precipitate was now boiled with much water, and the blue solution was evaporated to dryness. The residue from this evaporation is product No. 2, while the salt which remained insoluble in boiling water (*i.e.*, in as much as was applied) constitutes product No. 1. The mother-liquor of the first precepitate was evaporated as long as precipitates were found. These constitute product No. 3.

Quantation of Copper in the three products.

No. 1. 0·2325 g gave 0·0555 CuO = 19·05 % Cu.
No. 2. 0·408 g gave 0·1035 CuO = 20·26 % Cu.
No. 3. 0·422 g gave 0·103 CuO = 19·5 Cu.

The latter amount of copper is almost that required by cupric dileucin. The solution obtained by decoction of the first precipitate contained probably some amido-acid of lower atomic weight, which raised the amount of copper to 20·26 %, while the residual salt probably contained an amido-acid of higher atomic weight than leucin, whereby the amount of copper was depressed to 19·05 %. These hypotheses will have to be further tested on larger quantities of material.

Organic Body from Mercuric Chloride and Soda Precipitate.

The white precipitate was decomposed with hydrothion, and the solution left a semi-crystalline substance. This was insoluble in sprit of 85 °/c strength. In its watery solution phospho-wolframic acid produced no precipitate, showing that it was not and did not contain any alkaloid. Alkaline copper solution on application of heat gave no reaction. Ferric chloride produced a brown precipitate, soluble in excess of chloride, with an intensely red colour. Ammoniacal silver solution gave no precipitate, but on boiling it deposited reduced silver. Copper acetate gave no precipitate even on addition of alcohol. Acetate of lead gave a precipitate only after the addition of much alcohol, and this compound seemed to be an alcoholate. When dry it was found to contain 57·8 % of lead. It was therefore probable that the body was not and did not contain either glutaminic or asparaginic acid.

VI.—Properties of Common Tasteless Leucin and of its Copper-Compound, studied with a view of establishing its Diagnosis from its Isomer Glycoleucin.

Some tasteless leucin, made from albuminous matters (not brain) by the sulphuric acid process, which had been kept in the collection of the laboratory for some time, was again subjected to a process of purification. Some *tyrosin* again crystallised out with the first crystals. The solution was now treated with cupric acetate, and the first precipitate was removed. (In this any glycoleucin would have been contained.) The filtrate from the first precipitate on evaporation gave a precipitate (termed "first precipitate by evaporation," being second precipitate of copper-process), which was decomposed by hydrothion. The solution, on concentration, gave a first crop of crystals, which were rhombic plates, and *quite tasteless*. (Prep. 3072.)

This was again combined with copper, and the precipitate was filtered off. (The mother-liquor which gave no longer any precipitate with cupric acetate while hot, was lost.) The precipitate was now boiled with water repeatedly until it was completely dissolved, and the solution was filtered hot.

Quantations of Solubility.

(*a.*) 730 c.c. saturated boiling deposited, mainly immediately after filtration, and only to a small extent during cooling and standing for 24 hours, blue light crystals, which when dry, weighed 0·1790 g, indicating a deposit of one part out of 4,078 parts of boiling water.

(*b.*) Of the clear blue filtrate from the foregoing operation 630 c.c. were evaporated to dryness, and left 0·1048 g of blue compound, showing that one part was soluble in 6,011 parts of cold water. (The residue being in a large platinum basin could not be weighed in an absolutely dry state. The following quantation is more accurate :)

(*c.*) 100 c.c. on evaporation left 0·0162 grm. residue, equal to a solubility of one part in 6,172 parts of water.

Results: 730 c.c. of the leucin copper solution contained while saturated at the boiling heat 0·3000 g of salt; of this, 0·179 g were deposited on cooling, while 0·1210 g remained dissolved at the ordinary temperature. The solubility of the salt in boiling water is therefore one part in 2,433. This is about double the solubility of glycoleucin-copper.

It is generally stated in chemical writings that leucin dissolves in 27 parts of water at the ordinary temperature. I find by special experiment made with pure tasteless leucin, that one part dissolves in 30·07.

in round numbers 30 parts of water at 15° C. (Of glycoleucin, one part is soluble in 82 parts of water at 18° C.) It requires 658 parts of spirit of 75% strength for solution. Combination with copper therefore reduces its solubility very greatly.

The immediate deposition of crystals from a saturated leucin-copper solution filtered hot indicates the presence in the compound of ordinary or tasteless leucin; the hot saturated solution of glycoleucin-copper differs from the former in this, that it forms a deposit only after long standing.

Stability and Regularity of Composition of Leucin Copper-Compound.

A quantity (2·3 g.) of crystallised ordinary tasteless leucin, of similar origin as the foregoing, and separated from copper with which it had been combined, was a second time converted into the copper-compound by means of copper acetate. The compound was extracted several times with boiling water, and then dissolved entirely in a sufficiency of boiling water. Soon after filtration there separated from the still hot solution *a crystalline deposit*, which increased only slightly while the liquid cooled to the ordinary temperature of the air. The precipitate was isolated and dried at 110° (Prep. No. 3225), 0·2977 gave 0·0714 CuO = 19·15% Cu. The solubility of this precipitate in boiling water was as follows: 200 c.c. of boiling solution saturated by long boiling with excess of salt left 0·0904 residue, equal to a solubility of one part in 2,212 parts of boiling water. The cold solution filtered from the precipitate on evaporation left a residue, which showed that one part had been dissolved in 5,882 parts of water.

The *solution* in which the crystalline deposit, described in the foregoing, had been formed, was evaporated to a small bulk as long as it formed any deposit while hot, and then allowed to cool. The isolated (here termed second) precipitate dried at 110° (Prep. No. 3226) was analysed, 0·3338 g. gave 0·0818 CuO = 19·57% Cu. 200 g. of cold water dissolved 0·0432 g. of this compound, which is equal to a solubility of one part in 4,630 parts of water.

The filtrate from the second deposit just described was evaporated to dryness to obtain the remainder of the leucin compound. Some copper compound, differing in appearance from the leucin compound, was deposited *with* the latter, and had to be removed by water acidulated with a little acetic acid. This, as the quantation of the copper contained in the compound (Prep. No. 3227) showed, succeeded only partially, for 0·3532 g. left on ignition 0·0902 CuO = 20·39% Cu.

Thus it will be seen that the very first crystals of this preparation (reconstituted a second time as copper-salt, after having been constituted the first time as copper-salt, with an apparently pure specimen of leucin) contained a little less copper than is demanded by theory; the second crystals, obtained by concentration, yielded the theoretical amount of copper; and the third fraction was evidently impure by the admixture of a copper-salt, which was perhaps a combination of an amido-acid of lower atomic weight than leucin.

In connexion with this it deserves to be mentioned that the presence in leucin of tyrosin as an impurity depresses the amount of copper which will be found in the copper-compound made from such leucin. 11·2 g of crystallised leucin were treated in boiling watery solution with copper acetate, and the deposit was collected. It gave on analysis (mean of two quantations) 17·25% Cu. The filtrate on further evaporation and cooling gave another deposit, which on analysis was shown to contain 18·18% Cu. Another 11·2 g. of the same leucin as that used in

the experiment just related, was dissolved in a large quantity of warm water, and allowed to cool slowly, when it deposited a sensible portion of *tyrosin*. The leucin was now removed by the copper-process, and the compound found to yield the theoretical amount of copper. The mother-liquors of the first and the second part contained a copper-salt of a lower amido-acid, which had a sweet taste, but was not glycoleucin.

Note.—This and similar copper-salts, not yet exactly identified, retain tyrosin in solution. When the copper is now removed by hydrothion, the filtrate, reduced to the same bulk as the original solution, deposits *tyrosin* (Prep. No. 3036). This first deposited tyrosin gives a good mercurous nitrite test, but may contain some of the following *new body*. When the mother-liquor of the foregoing tyrosin is slightly evaporated, it deposits a body much like tyrosin, crystallising in microscopic fine needles, but giving no mercurous nitrite reaction; a slight rose pink which appears at the moment when the reagents are mixed, disappears, and the mixture becomes white.

Leucin obtained by Crystallisation from Amido-Mixture from Chemolysis of Brain-Albumin.

Although this leucin had no distinctly sweet taste, it was treated with copper acetate to separate any glycoleucin which might be contained in it. It was dissolved in hot water and heated to boiling; a concentrated solution of copper-acetate was now added gradually until a precipitate was formed. This *first precipitate* was removed by the filter. To the filtrate was added copper-acetate as long as a precipitate was produced, and then a slight excess of the acetate. The mixture was allowed to stand and deposit the *second precipitate*. This was collected on a filter. The *filtrate* was evaporated to a small bulk, and deposited, particularly on cooling, *a third product*. This latter appeared the most crystalline, and of the deepest blue colour.

The first precipitate was then boiled seven successive times with large quantities of water to extract the common leucin copper-compound, and leave any glycoleucin copper-compound insoluble behind. It was then dried on the filter; lastly in the air-bath at 110°, and analysed (Prep. No. 3223A) 0·3092 g. left after prolonged ignition 0·0759 CuO, equal to 19·60 % Cu, or exactly the theoretical amount for cupric dileucin.

The second precipitate was boiled with nine successive large volumes of water, and what remained undissolved (Prep. No. 3223B) was analysed, 0·3860 dried at 110°, left 0·0942 CuO = 19·49 % Cu.

The third precipitate which crystallised out of the concentrated mother-liquor of the first and second precipitate, was finely triturated in a mortar, washed with cold water, dried at 110°, and analysed (Prep. No. 3224) 0·3157 g, left 0·0775 CuO = 19·60 % Cu (again exactly the theoretical amount required by cupric dileucin).

The first and second precipitate were united, suspended in boiling water, and decomposed by a current of hydrothion. The bulk of the copper-sulphide was removed by filtration; the hazy and coloured liquid was evaporated to collect and precipitate some copper-sulphide (which is frequently imperfectly precipitated from neutral organic liquids), and after final filtration evaporated to crystallisation. The latter process was aided by the addition of some strong alcohol. The crystals were collected, and recrystallised from water and alcohol and dried in the air-bath. On elementary analysis they yielded results agreeing closely with the theory of pure leucin.

VII.—On Glycoleucin, the first Chemolytic Isomer of Leucin, its Properties and Combinations.

Synthetical and chemolytical glycoleucin.

Glycoleucin has been obtained by me in two ways, namely, synthetically, and by the chemolysis with baryta of brain albumins. I have not obtained it from animal albuminous matters by the sulphuric-acid process, which yields ordinary tasteless leucin.

Mode of isolating chemolytical glycoleucin.

The mode in which it is separated is the following:—The mixture of the several leucins, obtained by crystallisation from the amido-mixture, is combined with copper, by treatment with acetate. The glycoleucin copper-compound is mainly deposited with the first part of the precipitate; later, a mixture is deposited; lastly, mainly the compound of ordinary leucin. The copper-compounds which result are then exhausted with boiling water. The glycoleucin copper-compound, as the least soluble, remains behind, and is ultimately almost insoluble in boiling water. Much glycoleucin copper of course dissolves with the compound of ordinary leucin. The latter can to a large extent be isolated by the property that it separates from the boiling saturated solution in water almost immediately after filtration, while the saturated boiling glycoleucin copper solution does not deposit the excess of its salt until after long standing. It will be evident that these processes can only yield small quantities of material at a time. Seven specimens of glycoleucin copper were decomposed by hydrothion, &c., and crystallised separately. Three of the crystallised products were subjected to elementary analysis, and showed the identity of their composition with that of leucin. The seven specimens of crystals were then united (they weighed 7·53 g.) and dissolved in boiling water. To the boiling solution a concentrated cold solution of cupric acetate was added, not in excess. A sky-blue precipitate ensued, and was filtered off while the liquid was hot. To the filtrate, while cooling, a further quantity of cupric acetate was given, until no further precipitate was produced.

Precipitate No. 1.—Dried at 110°; 0·4542 g after combustion left 0·1092 CuO = 19·20 % Cu.

Precipitate No. 2.—Dried at 110°; 0·4210 g left 0·1026 CuO = 19·45 % Cu.

An eighth specimen of pure glycoleucin was combined with copper, and the compound on analysis gave 19·45 % of Cu (Prep. No. 3220). The mother-liquor of this on concentration yielded a preparation (No. 3221) which on analysis was found to contain 19·42 % Cu.

These data agree pretty closely with the theory of monocupric dileucin which contains 19·60 % Cu = 2 ($C_6H_{12}NO_2$) Cu or $C_{12}H_{24}CuN_2O_4$.

Solubility of the Cupric Salt of Glycoleucin in Cold Water.—Pure salt was boiled for a long time with water; the mixture was allowed to cool; when quite cold the solution was filtered from the compound. 200 c.c. at 16·5° C. on evaporation left 0·0228 g, equal to a solubility of one part in 8,772 parts of water. The solubility of ordinary leucin copper is one part in 6,172 parts of water, and is therefore greater than that of glycoleucin copper.

During the operation no trace of reduction or blackening was observed, not even when the solution of the compound was evaporated to an extremely small bulk with excess of cupric acetate. (This constitutes a diagnostic difference from the bearing of a more soluble sweet product which is obtained from the mother-liquors of the amido-mixture, and during the evaporation of which with copper acetate such a reduction takes place.)

App. B. No. 5.

Further Researches on the Chemical Constitution of the Brain; by Dr. Thudichum.

Solubility of the Cupric Salt of Glycoleucin in Boiling Water.—200 c.c. of the boiling solution left on evaporation to dryness 0·0449 g, or one part dissolved in 4,454 parts of boiling water. This is about double the solubility of the salt in cold water. On cooling, the solution becomes only slightly opaque; a long time is required for it to deposit the salt soluble in the hot as a visible precipitate.

Crystallisation of copper compound.

The glycoleucin copper compound crystallises in minute scales and plates, combined in masses or balls. Many of the scales are clearly rhombic, others rhombo-hexagonal; the relative angles could not easily be measured. The imperfect nature of these crystals is explained by their rapid deposition out of a medium in which they are so very little soluble.

Elementary Quantation of Glycoleucin, prepared from insoluble Copper Salt.—The copper was removed by hydrothion, and the glycoleucin obtained pure and pearl-white by repeated crystallisation. It was dried over calcium chloride, and at last at 110° C.:—

(*a.*) 0·3055 g. gave 0·2755 H_2O, and 0·6152 CO_2, equal to 54·92 % C and 10·02 % H.

(*b.*) 0·3131 gave 0·2342 metallic Pt, equal to 10·61 % N.

(*c.*) 0·4555, burnt with CuO in CO_2, &c., gave 230·5 m.m. gas at 13° T. and 773·5 m.m. B. equal to 41·520 c.c. of N. at 13° and 773·5, equal to 38·919 c.c. of N. at 0° and 760 B. Weight of N= 0·048826 g = 10·72 % N.

Synopsis of Theory and Data.

	At. Wts.	Per cent.	Found. (*a.*)	Found. (*b.*)	Found. (*c.*)
6 C	72	54·96	54·92	—	—
13 H	13	9·92	10·02	—	—
N	14	10·69	—	10·61	10·72
2 O	32	24·43	—	—	—
	131	0·00			

Glycoleucin does not give the inosite reaction with mercuric nitrate.

Solubility in Water at 18°.—7·4460 g of the saturated solution, from which glycoleucin had crystallised, left 0·0910 g crystallised white glycoleucin. 100 parts by weight of solution retain 1·22 parts of glycoleucin in solution, or in round numbers one part is soluble in 82 parts of water. Glycoleucin is therefore much less soluble in water than common tasteless leucin, of which 1 part requires 30 parts of water for solution at 15°.

Taste of glycoleucin.

The sweet taste of glycoleucin is less easily perceived on the crystals than on their saturated solution. Of this one drop will give a distinctly sweet taste over a great part of the mouth. The intensity of the sweetness is not much less than that of inosite.

VIII.—On some New Alkaloids obtained from Brain-Albumin by Chemolysis.

Ingredients of amido-mixture.

The amido-mixture, which is obtained from brain-albumin by decomposition with baryta under pressure yields on first crystallisation leucin, glycoleucin, tyrosin, and some amido-acids of lower atomic weight than leucin. But there remains a considerable part of the mixture which does not crystallise in the state of mixture, each ingredient of which,

however, seems crystalline after complete separation. I have isolated two of the ingredients and give in the following a short description of their isolation and their properties.

Mode of Isolation of Alkaloids from Amido-Mixture.—The mother-liquor of leucin is diluted, acidified with sulphuric acid, and mixed with an acidified solution of phospho-wolframic (syn. phosphotungstic) acid, as long as a precipitate is produced. The latter is washed with water containing 5 % of oil of vitriol, by decantation, ultimately on the filter. It is then decomposed with hot baryta solution, the excess of baryta is removed by carbonic acid, and the resulting solution of alkaloids is evaporated to a syrup. This product has the following properties and reactions:—It is strongly alkaline; has the smell of sperma; is soluble in ammonia water; does not reduce potassio-cupric tartrate. With hydrochloric acid and gold chloride it gives a copious precipitate, which is insoluble in excess of acid, easily soluble in alcohol. Hydrochloric acid and platinic chloride give no precipitate in watery solution, but in alcohol a precipitate is produced. Zinc chloride gives a copious white precipitate, which is soluble in excess of the chloride and in hydrochloric acid. Silver nitrate gives a voluminous white precipitate, soluble in nitric acid. Tannin gives a voluminous white precipitate. Mercuric chloride produces a striking phenomenon. When to its saturated solution a drop of alkaloidal matter is added, the whole surface is instantly covered with a white precipitate. (The matter precipitated is therefore not spermatin, which gives only a turbidity with mercuric chloride. (Ann. Chem. Med., I. 306.) The alkaloidal matter is carbonated, as on addition of an acid carbonic acid is evolved. It also contains some barium not precipitable by carbonic, precipitable by diluted sulphuric acid.

Properties of the new alkaloids.

Separation of the Alkaloidal Matter into two Groups by Absolute Alcohol.—When the syrupy mixture of alkaloids is treated with absolute alcohol, a viscous matter remains insoluble, another portion dissolves in the alcohol. The matter insoluble in alcohol retains its solubility in water. The matter soluble in alcohol gives with platinic chloride a copious precipitate of a double salt. This is not changed by alcohol, but is altered quickly by water. It fuses after evaporation of the alcohol. Placed in water it practically dissolves, a part remains undissolved. The solution in water continues to form deposits, for weeks, of the insoluble salt. Owing to this lability I have not examined these two platinum salts any further.

From the viscous matter precipitated by alcohol there was obtained by a process of continued crystallisation a white crystallised *alkaloid*, very soluble in water, easily soluble in hydrochloric acid. The hydrochlorate evaporated to dryness, and redissolved in water, crystallises from concentrated solution. From spirit this hydrochlorate crystallises still better. The spirit solution may be mixed with ether without yielding a precipitate. But the crystals of the hydrochlorate are not very soluble in ether and may be washed with it. The salt, mixed with mercuric chloride and then with caustic soda, gives a white precipitate soluble in excess of the soda.

New crystallised alkaloid.

Elementary Quantation of this new Alkaloid.

After removal of the hydrochloric acid the free body crystallises in balls of needles. Dry at 110°.

(1.) 0·2374 gave 0·4712 CO_2 and 0·1930 H_2O, equal to 52·99 % C and 9·03 % H.

(2.) 0·1926 burnt with soda lime gave 0·1344 Pt. = 0·01906 N = 9·896 %.

These data lead to the following provisional theory :—

	Per cents.	÷ At. Ws.	÷ N = 1
C	52·99	4·4158	6·3
H	9·03	9·03	12·9
N	9·896	0·7068	1·
O	28·084	1·755	2·5
	100·000		

These relations of elements remind of a *leucein* (rather than a leucin), with which probably a small quantity of a high homologue is mixed.

Separation of the Alkaloidal Matter into two Groups by Cupric Acetate and Absolute Alcohol.

When the mixture of alkaloids is dissolved in little water and mixed with a saturated solution of cupric acetate and warmed no precipitate of leucin-copper ensues if the process of precipitation by the phosphotungstic acid has been correctly conducted. On continued warming some brown cuprous and dark cupric oxyde are deposited. The deep blue solution filtered from all deposits, is mixed with absolute alcohol as long as this agent produces a precipitate. This is the copper-compound of a new alkaloid, which without further purification, on analysis gave the following preliminary results :—

(1.) 0·2451 g. burnt with CuO gave 38·23 % C, and 5·91 % H.
(2.) 0·5072 gave 10·57 % N (by Pt. salt).
(3.) 0·7440 gave 10·65 % N.
(4.) 0·4318 gave 0·0838 CuO = 15·50 % Cu.
(5.) 0·5482 gave 0·1077 CuO = 15·69 % Cu.

Synopsis of Result and Theory.

	Per cents.	÷ At. Ws.	÷ Cu = 1
C	38·23	3·186	12·95
H	5·91	5·91	24·
Cu	15·60	0·246	1·
N	10·61	0·757	3·
O	29·65	1·853	7·53
	100·00		

Leading to formula $C_{12}H_{23}CuN_3O_7$, or $C_{12}H_{23}N_3O_6 + CuO$. The salt has a very light blue colour; it is easily soluble in water, and the solution has a very dark blue colour. It contains a trace of probably tungstic impurity, which remains undissolved when the copper oxyde is dissolved in nitric acid.

Alkaloids soluble in absolute alcohol.

The alkaloids which are soluble in absolute alcohol in the presence of cupric acetate have not yet been isolated. They contain, of course, the bodies which give the platinum compounds above described. I have subjected them to numerous reactions, and have isolated some peculiar bodies, of which the following is an example taken from my note-book.

(Prep. No. 3031.) New body, alkaloid, by mercuric chloride and caustic soda from syrupy part of alkaloids after copper acetate and mercuric chloride treatment. The ***white mercury compound*** became grey on standing; it was decomposed by hydrothion, and the filtered solution was evaporated. The deposits which formed on concentration

were filtered off three times. They appeared under the microscope as amorphous granules, almost insoluble in absolute alcohol even on boiling; easily soluble in nitric acid, but not precipitated from this solution by silver nitrate; in this mixture excess of ammonia produces no precipitate, and no change ensues on its being boiled (absence of hypoxanthin). The nitric acid solution of the body on evaporation leaves a yellow residue, but by no manipulation can a red colour be produced, as with the xanthin bodies. This compound must be produced in quantity before it can be studied with advantage.

These alkaloids were not observed by Schützenberger in the researches on the chemolysis of various albuminous substances of which I have given an abstract in Ann. Chem. Med. I., p. 20 to 44. They will therefore have to be added to the list of terminal cleavage products after they are better known and identified.

IX.—Quantation of the Chemical Constituents of Grey Tissue from the Human Brain.

Grey tissue was carefully cut from the surface of both hemispheres, and from the anterior and posterior lobes of each. 6·2395 g were dried at 95° until the weight was constant. The substance was repeatedly cut up with a knife. The dry residue weighed 0·9193 g = 14·73 %. The water lost amounted to 5·3202 g = 85·27 %.

For the following operations another quantity of grey tissue, amounting to 46 g fresh, was cut from all parts of the brain. It was extracted five times with boiling spirit in a flask attached to a reflux cooler.

The *albuminous residue*, dry, weighed 3·5 g equal to 7·6 % of the fresh grey tissue. It was analysed for sulphur and phosphorus. 1·5304 g were burnt with addition of baryta-water, and gave 0·0024 $BaSO_4$ = 0·02 % sulphur, and 0·0325 magnesium pyrophosphate = 0·60 % phosphorus.

The *deposit* which the spirit made on cooling (cerebrins, &c.) weighed 0·3 g.

The *spirit solution* evaporated to half its bulk, gave a (second) deposit which weighed 0·1 g.

The *filtrate* from this was evaporated to a small volume and deposited (a third deposit weighing) 0·7 g.

The foregoing deposits (0·3 + 0·1 + 0·7, total = 1·1 g.) were extracted with ether. There remained 0·2 insoluble, 0·9 were soluble in ether. The matter soluble in ether (previously deposited from spirit) amounted to 1·950 % of the fresh tissue, while the matter insoluble in ether (cerebrins) amounts to only 0·434 % of the tissue.

The *last oily matter*, which could not be filtered from the water extract in which it was suspended, was precipitated with lead acetate; the curded precipitate was collected on a filter.

The *precipitate of lead-salts* contained the phosphorised organic compounds and sulphuric and phosphoric acid from the inorganic salts. It was washed while being continuously stirred with water to which a little lead acetate had been added. It was next extracted with absolute alcohol. The alcoholic solution contained all the *lecithin* (with some lead). The dry matter weighed 0·73 g.

The insoluble in alcohol residue was completely dried and extracted with ether. The solution on distillation left all *kephalin-lead*, which weighed 0·22 g.

The insoluble in ether residue was extracted with boiling alcohol, which dissolved all *myelin lead*, and this when dry weighed 0·03 g.

The residue from the three extractions with alcohol, ether, and boiling alcohol was mainly an inorganic lead-salt. It was exhausted with dilute nitric acid, and the insoluble residue, a mere trace of matter, was recognised as *lead sulphate*. The matter soluble in nitric acid was analysed for phosphorus by ammonium molybdate, &c., and gave 0·0175 g. pyrophosphate of magnesium, equal to 0·0049 P. The *phosphoric acid* thus indicated was evidently combined with alkalies in the grey tissue.

The lead-salts from the mixture of the last oily matter and watery extract obtained as just described are liable to contain some *inosite-lead* as an insoluble compound. When this is decomposed in warm absolute alcohol by hydrothion, an alcoholic solution is obtained from which, on long standing, and again after concentration, *inosite* is deposited in crystals. I have carefully identified these crystals, by their taste, their shape, and their reaction with mercuric nitrate. It is therefore clear that inosite can be precipitated, under the conditions prevailing in this research, by neutral acetate at least in part. Its complete precipitation can be effected only by basic acetate, and that with the aid of ammonia. These difficulties, which at least double the operations necessary for the quantation of inosite, have caused me to search for other methods for its isolation. Of these endeavours some results are given in another chapter.

The watery solution was freed from lead by hydrothion, condensed to expel acetic acid, acidified with sulphuric acid, and extracted with ether. The extract gave by the usual treatment *zinc lactate* in crystals, which weighed 0·07 g equal to 0·0452 g lactic acid in 44 g grey tissue, or 0·102 %; in round numbers, one part of lactic acid in a thousand of grey tissue.

The solution from which lactic acid had been extracted was treated with ammonium carbonate in excess, and gave clear indication of the presence of *calcium*. But the quantity was too small for being weighed. The filtered solution was boiled to expel ammonia, and then treated with phospho-molybdic acid. A precipitate of *alkaloids* or extractives was obtained weighing 0·530 g.

From the filtrate all phosphomolybdic and sulphuric acid were removed by baryta. The filtrate treated in the usual way and evaporated to dryness left a residue, being *inosite and carbonates of alkalies* weighing 0·69 g. It gave with mercuric nitrate the inosite reaction. The residue was dissolved in water, and precipitated by lead acetate and ammonia. The precipitated inosite lead was isolated and decomposed by hydrothion.

The mother-liquor of inosite lead was freed from lead, evaporated, burnt, &c., and left mixed carbonates of alkalies, which were transformed into chlorides = 0·2560. Out of this quantity platinic chloride precipitated 0·070 double chloride = 0·0112 K = 0·0250 % K in grey tissue. The remaining sodium amounted to 0·0920 % of grey tissue.

Synopsis of the Results of Analysis of Grey Matter of Human Brain.

	Per cents.
Water expelled at 95°	85·270
Albuminous part	7·608
Ether extracts, kephalin, and lecithin (and cholesterin ?)	1·950
Cerebrins and myelin	0·434
Lecithin, Kephalin, Myelin (from last oily (and cholesterin ?))	0·780

	Per cents.
Inosite	0·193
Lactic acid	0·102
Alkaloids	
Sulphuric acid	traces
Phosphoric acid, H_3PO_4	0·017
Potassium	0·025
Sodium	0·092
Water extract	0·500
Loss in operations	

The loss in operations is very large, amounting to almost a quarter of the entire solids. It is mainly incurred through the difficulty which there is of separating the last oily matter from the matter soluble in water. But other operations equally involve as yet unavoidable loss. The construction of suitable apparatus for ether extraction would only partly avoid the loss by ether extraction, as in this process the main difficulty is filtration. Loss in operations.

The *inosite* isolated weighed 0·09 g = 0·193 %.

Quantation of the Chemical Constituents of the White Tissue of the Human Brain.

The parts to be analysed, amounting to 66 g, were cut from the centre of the hemispheres and corpus callosum. They were triturated to a pulp, mixed with spirit and extracted six times with boiling spirit.

The *spirit extract* deposited a white *cerebrin substance* on cooling, which was collected and washed. It was then extracted with large volumes of ether and filtered again. It weighed, dried at 70°, 4·5615 g, equal to 6·91 % of the fresh white brain-substance. Further treatment of the cerebrin bodies see below.

Ether extract of the cerebrin deposit.—The ether was distilled off, the concentrated solution was filtered from a trifling deposit, and distilled to dryness. The residue weighed 2·4150 g.

The ether extract of the albuminous substance (made after exhaustion by spirit and drying) on concentration deposited a few oily drops, and on distillation to dryness left a residue weighing 0·0350 g. It became dark, and existed only as a minute brown coating on the glass, possibly a mere trace of phosphorised substance, too small in quantity for further treatment.

The albuminous residue was dried and weighed, after the treatment with ether, = 5·70 g. equal to 8·63 % of original white brain substance.

The *spirit extract* which had deposited the white matter was concentrated twice in succession, and after each concentration deposited a semi-crystalline buttery matter. Of this the ether extract weighed 5·1730 g while the part insoluble in ether weighed 0·1400 g. Of this a part was soluble in boiling spirit, and deposited on cooling, while a dark part was insoluble in boiling spirit, and contained some inorganic matter and phosphorus (probably myelin and a myelin salt).

The *cerebrin mixture* above described, weighing 4·5615 g, was dissolved in boiling absolute alcohol, when 0·1815 g of coloured matter, which was insoluble in benzol, and therefore was not stearoconote, remained undissolved = 0·275 % of tissue. (It amounted to 3·9 % of the cerebrin mixture, and besides some slight impurity was albumen).

The dissolved part deposited on cooling and standing phrenosin, kerasin, cerebrinic acid, with some phosphorised matter, and retained a phosphorised matter in solution. The dry cerebrins weighed together 2·6030 (equal to 3·94, in round numbers 4 % of the white tissue).

The alcoholic solution, from which these cerebrins had been deposited, measuring 750 c.c., contained 1·770 g of matter dissolved. With this

some attempts at an identification and quantation were made. Out of one half, 375 c.c., a precipitate was obtained with the aid of alcoholic platinic chloride; the precipitate dried at 65°, weighed 0·4524 g, and contained phosphorus = 2·52 %. The second 375 c.c. were precipitated with alcoholic cadmic chloride; the precipitate weighed = 0·2965, and contained phosphorus = 4·78 %.

Analysis: (*a.*) 0·4462 $PtCl_4$ salt were fused with caustic and flux and yielded 0·0402 magnesium pyrophosphate = 2·52 % P.

(*b.*) 0·2965 $CdCl_2$ salt were fused, &c., and gave 0·0508 magnesium pyrophosphate = 4·78 % P.

The cadmium salt therefore contained much more phosphorus than the platinum salt, in other words they contained different organic ingredients. Moreover the precipitants brought down only about one sixth part of the matter in solution in absolute alcohol. The mother-liquors were concentrated and made deposits, which were examined, but the results are not of a nature to be quoted in this place.

The quantity of matter which had remained soluble in the absolute alcohol was ascertained as follows:

Total crude dry cerebrin mixture - -	4·5615 g.
Deduct albumen left insoluble in absolute alcohol - - - - -	0·1815 „
Leaves pure cerebrin mixture - -	4·3800 „
Deduct the cerebrins deposited from absolute alcohol - - - -	2·6030 „
Leaves cerebrins, myelin, kerasin, soluble in cold absolute alcohol - -	1·7770 „

These latter substances, which remain dissolved in much absolute alcohol, therefore amount to 2·6 % of the white tissue.

The last oily matter which was suspended in the aqueous extract could not be separated by filtration. This is one of the greatest difficulties of brain analysis, and will have to be overcome by further discovery. In the interval I have adopted the following process, which is efficient in all directions except on the point of inosite, as I have already stated above. The mixture was treated with lead acetate; the precipitate was dried and weighed 0·7340 g. It was extracted with cold absolute alcohol. The extract weighed 0·4820, and was mainly *lecithin*, with some lead.

The part insoluble in cold absolute alcohol was extracted with ether; the solution left a residue of *kephalin lead*, weighing 0·0230 g.

The part insoluble in ether was mainly *myelin lead*, but contained some sulphuric and phosphoric acid. It weighed = 0·1970 g.

The watery filtrate from the lead precipitate was freed from lead by hydrothion, evaporated to dryness and left residue 0·9260 g. This was redissolved in little water, and acidified with sulphuric acid. The mixture was extracted with ether, and the extract treated for lactic acid, with zinc, &c. The zinc lactate crystallised white weighed = 0·0707 g dried over oil of vitriol in vacuo.

The acid solution from which the lactic acid had been extracted was precipitated with phosphomolybdic acid and the precipitate filtered off and dried = 0·1270 g.

The filtrate from this was treated with baryta, &c., and after treatment with ammonium carbonate and evaporation left a residue weighing 0·7500. This was redissolved in water and precipitated with basic lead acetate. Inosite lead was isolated and decomposed with hydrothion. The dry inosite, crystallised, weighed = 0·1420.

The mother-liquor was freed from lead, evaporated to dryness, burnt, and the residue weighed = 0·1717 g; of the metals in this 17·67 °/₀ were potassium, and 82·33 °/₀ sodium.

Synopsis of the Results of Analysis of White Tissue of Human Brain.

Water expelled at 95°	70·230
Albuminous part	8·630
Ether extracts, kephalin, lecithin, and cholesterin	11·497
Cerebrins and myelin	6·910
Insoluble in ether from buttery	0·212
Lecithin (lead)	
Kephalin (lead)	
Myelin (lead)	
Water-extract, 1·403 per cent. consists of	—
Lactic acid	0·0456
Inosite	0·2151
Alkalies (carbonates)	0·1717

The separation of the ether extracts into their constituents was also carried out, and the results will be stated lower down.

X.—Quantation of the Absolute and Specific Gravities of a Human Brain and of several Parts.

Division of the Brain.	Absolute Weight in Air.	Weight in Water.	Loss of Weight in Water.	Specific Gravity.
1. Right hemisphere	589·035	20·820	568·215	1·037
2. Left hemisphere	595·823	21·600	574·223	1·038
3. Cerebellum	135·172	5·030	130·142	1·039
4. Mesenkephalon	33·950	1·250	32·700	1·038
5. Sclerotic part	3·630	0·150	3·480	1·043
Entire Brain	1357·610	48·850	1308·760	1·037

Quantation of the Specific Gravity of White Tissue and Grey Tissue of the Human Brain.—These specific gravities were ascertained by suspension of the parts in water, &c. (grammes at 16°).

White Tissue.

Weight in Air.	Weight in Water.	Specific Gravity.
0·4870	0·0258	1·053
0·8650	0·0400	1·048
1·0746	0·0477	1·046
0·6859	0·0310	1·044
1·0479	0·0394	1·039
3·7845	0·1319	1·036
9·7000	0·2850	1·030
9·5362	0·2740	1·030

Grey Tissue.

0·6628	0·0243	1·038
14·4592	0·3810	1·027
11·5741	0·2865	1·025

The foregoing data have been arranged in the order of decreasing specific gravities. This led at once to an inverse order in the column denoting weights in air. Only two figures out of eleven do not absolutely take the places which they would occupy if the order of increase in the first column was inverse as that in the third.

From the foregoing data it therefore appears, what has also been confirmed by many other experiments, some to be related below, that *the specific gravity of white and grey tissue of the brain is found the higher, the smaller is the quantity of brain-tissue employed in the experiment.* Now, as the pieces of tissue which can be employed in the experiments are limited in size by the arrangement of the relative tissues in the brain, it is clear that the specific gravity quantations of brain-substance in water can only be approximately correct. The variations, no doubt, depend upon a reaction between the surface of the piece of tissue immersed and the water which surrounds it. The water takes up some soluble albumin and some salts, and the piece of brain-tissue immersed assumes a glazed appearance. It is evident from this that the greater the surface of the piece under observation to its volume, the greater will be the effect of this source of error. The error will further be influenced by the length of time during which the piece of tissue is immersed, and consequently variations will arise, even when pieces of equal size are examined, from the interference of the accident of quicker or slower weighing. It is further doubtful whether white and grey tissues will be equally influenced by water in the same time, even when their bulks are equal. It is further not proved that either the grey or the white tissue is so homogeneous in any part of the brain as is assumed for the purposes of comparison. It is therefore clear that specific gravity estimates of brain-tissue in water have only an approximative and no absolute mathematical value. Such estimates must therefore be made with the aid of fluids of well-known specific gravity, which, while they make contact with the brain-tissue, do not provoke in it any chemical or physical changes.

Quantations of the Specific Gravities of White and Grey Tissue from different parts of the Brain.

White Tissue of Hemispheres.

(*a.*) *Quantations by the Piknometer.*—

Absol. Weight.	Subst. + Pik.	Pik. + Water.	Spec. Grav.
0·4526	61 9300	61·9120	1·041
0·2817	61·9342	61·9198	1·054

(*b.*) *Quantations by Suspension in Water.*—

Absol. Weight.	W. in Water.	Spec. Grav.
0·6859	0·0310	1·044
1·0479	0·0394	1·039
3·7845	0·1319	1·036
9·5362	0·2740	1·030

Grey Tissue of Hemisphere.

(*a.*) *Quantation by Piknometer.*—

Absol. Weight.	Subst. + Pik.	Pik. + Water.	Spec. Grav.
0·3117	61·9146	61·9039	1·039

(*b.*) *Quantations by Suspension in Water.*—

Absol Weight.	W. in Water.	Spec. Grav.
0·6628	0·0243	1·038
14·4592	0·3810	1·027

White Tissue of Cerebellum.

(*a.*) *Quantation by Piknometer.*—

Absol. Weight.	Subst. + Pik.	Pik. + Water.	Spec. Grav.
0·5900	61·9240	61·9039	1·037

(*b.*) *Quantation by Suspension in Water.*—

Absol. W.	W. in Water.	Spec. Grav.
0·8650	0·0400	1·048

White Tissue of Mesenkephalon.

(*a.*) *Quantation by Piknometer.*—

Absol. Weight.	Subst. + Pik.	Pik. + Water.	Spec. Grav.
0·6849	61·9252	61·9039	1·032

(*b.*) *Quantation bp Suspension in Water.*—

Absol. W.	W. in Water.	Spec. Grav.
0·5128	0·0258	1·053

Synopsis and Averages of the Specific Gravities observed in the three Series of Observations detailed in the foregoing, without reference to repetition of the same numbers or to quantities on which they were observed.

I. *White Tissue.*

1. 1·054	5. 1·044	9. 1·036
2. 1·053	6. 1·051	10. 1·032
3. 1·048	7. 1·039	11. 1·030
4. 1·046	8. 1·037	

Mean specific gravity of white tissue = 1·041.

II. *Grey Tissue.*

1. 1·039	2. 1·038	3. 1·027	4. 1·025

Mean specific gravity of grey tissue = 1·032.
Specific gravity of entire brain (four parts) = 1·037.

The foregoing figures do not differ much from those accepted by other observers. The specific gravity of white tissue is the same as that commonly allowed in physiological treatises, namely, 1·041, while the specific gravity of grey tissue is 1·032 instead of that commonly allowed, namely, 1·034. But when it is considered that what must theoretically be assumed to be the best observations of the specific gravity of white tissue, namely, those on the largest volume, do only give 1·030 as the value, while grey tissue under the same limitation gives 1·027, it is impossible to avoid the suspicion that all specific gravity estimates hitherto made, including the foregoing, are vitiated by a fundamental fault of method, or by several faults, as above indicated. These probable faults have for the first time being observed in the course of the present researches, and there has been no time for remedying the inconveniences arising out of the observation.

In a former report* I communicated a then new method for estimating the proportion between white and grey tissue in the brain (an important physiological problem, which seems anatomically quite insoluble) by a calculation from the four factors, absolute weight of the brain, specific gravity of the entire brain, and specific gravities of each white

* Report of the Medical Officer of the Privy Council and Local Government Board, New Series, No. VIII., 1876, Appendix No. 6, p. 148.

and grey tissue. This method still has its future, if the difference between the specific gravity of white and grey tissue be not ultimately found too small.

In its execution the following formula may be used :—

$$x = \frac{P\,w\,(p-g)}{p\,(w-g)}, \text{ in which}$$

x = quantity of white matter.
P = absolute weight of the brain.
p = specific gravity of the entire brain.
g = specific gravity of the grey tissue.
w = specific gravity of the white tissue.

Applying this formula to the data given above, namely,—

$P = 1358$; $p = 1{\cdot}037$; $g = 1{\cdot}032$; $w = 1{\cdot}041$; then $x = 757{\cdot}3$, equal to 55 °/₀ of white tissue and 45 °/₀ of grey tissue in the entire brain.

XI.—Systematic quantitative Analysis of the Brain.

Mode of proceeding.

The brain is weighed in its membranes; the latter are then carefully removed and weighed, and their weight is deducted from the weight of the brain previously found. The membranes of a human brain will be found to weigh about 60 g. The brain-tissue is then cut, or minced in a machine, and steeped in alcohol, until it has become hard. It is then worked through a sief in the manner described in Rep. N.S., No. III, 1873, p. 114, et seq., where also an engraving of the apparatus is given. The brain pulp is now exhausted with spirit of 85 °/₀ strength. The boiling with spirit must be repeated until a litre of spirit boiled with the whole of the residue, filtered and distilled to dryness, leaves only an inappreciable residue. The first spirit extracts which deposit the particular white matter are kept separate. All particles of brain-tissue on the one hand and all portions of liquid on the other must be constantly collected with scrupulous care. A human brain will leave from 100 to 120 g of dry albuminous matter.

The alcoholic solutions of the first extractions deposit on cooling and standing *the white matter*, which amounts to 4·7 to 5 °/₀ of the mixed brain-tissues, but is mainly derived from the white tissue. (Compare on this subject the special analyses of white and grey tissue given in another chapter.)

Analysis of the white matter.—It is exhausted with ether, by being shaken with it in a stoppered cylinder, and allowed to settle; the ether is drawn off with a syphon worked by air pressure. The white cerebrin mixture, containing the cerebrin and some phosphorised matters, remains insoluble, while all kephalin, lecithin, some myelin, all cholesterin, and some other neutral matters, an oil or ether (cerebrol) and a yellow coloured matter, dissolve. Thus we have—

Soluble in ether.	Kephalin, part combined	-	all extracted.	
	Lecithin, do.	-	all ,,	
	Myelin, do.	-	part ,,	
	Cholesterin - -	-	all ,,	
	Neutral (new) matter	-	part ,,	(Kephalosterin,.
	Cerebrol - -	-	all ,,	
	Yellow coloured matter	-	all ,,	

Treatment of the ether Solution; separation of its Ingredients from each other.—The ether is distilled off, the liquid residue is mixed with an alcoholic solution of acetate of lead, and excess of alcohol and boiled

for some time under a refluent cooler. It is then allowed to cool and stand. The cholesterin crystallises in the upper layer of the mixture, while the kephalin lead and myelin lead remain below, insoluble. The mixture is gently warmed until cholesterin is dissolved and again allowed to cool. This process is repeated to cause the kephalin lead and the myelin lead to become as adherent and lumpy as possible, so that when the warm spirit solution is filtered off through a filter on a hot funnel, only a minimum of the insoluble compounds may pass on to the filter. The residue is then exhausted with spirit by repeated long boiling with it. Thus we have—

Insoluble in boiling spirit.	Kephalin lead - -	all precipitated.
	Myelin lead - -	greater part precipitated.
Soluble in boiling spirit Part.	Cholesterin - -	all.
	Myelin lead - -	part.
	Lecithin - -	all.
	Cerebrol - -	all.
	Yellow coloured matter	all.
	Neutral new matter -	all. (Kephalosterin).

Treatment of the insoluble in boiling Spirit part (of the Ether Extract boiled with Lead Acetate).—This contains all kephalin lead, and some myelin lead, which have to be separated. This is done by absolute ether, in which *kephalin lead* dissolves, with a red colour, while *myelin lead* remains as an insoluble white deposit. The latter is washed with ether by decantation mainly (with the aid of a syphon and air pressure) lastly on the filter, dried and weighed. This datum is *myelin lead part the first*. The kephalin-lead solution, and all ether used for washing myelin lead is distilled to dryness and the residue weighed. It constitutes kephalin lead, and contains all the kephalin which had been precipitated in the white matter.

In each, myelin lead and kephalin lead, the metal and phosphorus are ascertained by analysis, and from the data the amounts of pure myelin and pure kephalin relatively are calculated.

Treatment of the soluble in Spirit part.—The boiling solution is mixed with as much boiling water as it will bear without becoming precipitated, and is allowed to cool slowly. *Cholesterin* (and phrenosterin?) crystallises almost completely, somewhat later and covering the latter settles the *myelin lead*. *Lecithin* (? lead), cerebrol, yellow coloured matter, neutral new matters (kephalosterin) remain in solution. (This mixture requires further study.)

Separation of Cholesterin from Myelin Lead.—The isolated crystallised matter is pressed, dried, and placed in absolute ether in a tall stoppered cylinder, and frequently agitated. Cholesterin dissolves, while the lead salt of myelin and a cerebroside settle as a white deposit. The extraction of cholesterin is completed by the repeated application of large volumes of ether. The united ether solutions are distilled to dryness; the residue is dissolved in boiling dilute spirit (if not sufficiently dilute, the boiling solution must be mixed with boiling water until it becomes turbid) and the solution set to crystallise. The *cholesterin* is filtered off, dried, and weighed. The white salt which the ether dissolving the cholesterin has left insoluble, is *myelin lead*, and a cerebroside. This is dried and weighed. It gives the purple reaction with oil of vitriol alone on standing, immediately with sugar syrup.

The *spirit mother-liquor of the cholesterin*, after concentration, may yet yield a minute quantity of cholesterin, but does not contain much else, colouring matter excepted. It may be added to the principal mother-liquor, from which cholesterin and myelin lead were originally deposited.

Solution in Spirit of Lecithin (*? lead*) *cerebrol, yellow colouring matter, neutral matter* (*new, Kephalosterin*) *and some Cholesterin.*—Lecithin does not remain combined with lead in watery spirit. It cannot be separated from the rest of cholesterin except by precipitant reagents, or by chemolysis by which it is decomposed. Its quantation has been found to be effected, with the greatest approximation to truth, by the following process. The spirit solution containing the matter just named is heated until all the spirit is evaporated. The residue in then treated with boiling water, in which it hardens and becomes granular. (In cold water it swells and becomes pasty, so that it cannot be separated from its mother-liquor.) The hot water is now decanted, and replaced by new; the mixture is allowed to cool, heated again to make the solids curdle, and the water is again decanted; this is repeated until the decanted water is free from lead.

Chemolysis of the lecithin, &c. mixture with Baryta.—The mixture as described is now mixed with the necessary quantity of baryta hydrate and water, and chemolysed in a closed platinum tube under pressure at 125°, for at least six hours. The contents of the tube are extracted firstly with hot water, which removes excess baryta, *glycerophosphate of barium*, and *neurin*. The solution is neutralised with carbonic acid, and the filtrate is evaporated. When suitably concentrated, the addition of absolute alcohol to it precipitates all *barium glycerophosphate*, while the filtrate contain all *neurin*. The solution is neutralised by hydrochloric acid in excess, and the addition to it of alcoholic platinic chloride precipitates all neurin as platino-chloride hydrochlorate. Both salts, the barium glycerophosphate and neurin double salt are dried and weighed.

Products of the Baryta Chemolysis of the Lecithin Mixture which are insoluble in Water.—These are extracted with boiling spirit. The concentrated spirit solution deposits yet some cholesterin and a small quantity of a barium salt. These are removed by the filter. The cholesterin is separated from the barium salt by ether. The spirit solution now retains the bodies above mentioned, namely, two neutral crystallised bodies (which are here described for the first time) (*kephalosterin and another*), and perhaps some cerebrol and yellow colouring matter. *Kephalosterin* and the other body crystallise out of the absolute alcohol solution. Ether separates the second crystallised body from the kephalosterin. The latter is recrystallised from spirit. A thick mother-liquor remains, which requires further qualitative examination. It is dried and weighed, and placed in the account as *last product of chemolysis of lecithin mixture.*

That part of the product of the chemolysis of the lecithin mixture which is insoluble in water as well as boiling spirit contains *the baryta salts of the fatty acids* produced from the chemolysed *lecithin*, as well as from the chemolysed ethylic ethers of fatty acids resulting from a previous partial decomposition of lecithin under the influence of heat and alcohol only. As they contain barium carbonate they have to be reconstituted in a pure state, and the different fatty acids have then to be separated. This is best done by decomposing the salts in water with hydrochloric acid, and extracting the fatty acids with ether. The ether is distilled off, the fatty acids are dissolved in watery ammonia, and precipitated as lead salts by lead acetate. The lead salts are dried, powdered, and exhausted with ether. The ether solution on distillation leaves *lead oleate*, while the salt insoluble in ether will be found to be mainly *lead palmitate* or *margarate*, with only little, if any, *stearate*. From the oleate and palmitate, with the aid of the neurin and glycerophosphate, the amount of lecithin originally present is easily calculated.

Treatment of the Alcoholic Solution which has deposited the White Matter.—This solution, and all alcoholic extracts of the albuminous part obtained until it is exhausted, are distilled together to a convenient state of concentration, and allowed to cool. A matter is then deposited, which, from its consistency, has been called "*buttery*," and which consists of cholesterin, lecithin, kephalin, myelin, and some other ingredients. This is separated from the liquid by filtration, and analysed as will be described.

Treatment of the concentrated Alcoholic Solution which has deposited the Buttery Matter.—This solution is evaporated on the water-bath until all alcohol has disappeared. The last portions of phosphorised matters and cholesterin, together with small quantities of oily ethers, then float on the watery liquid and adhere to the evaporating dish. This product is termed the "*last oily*." It is most advisable to separate this from the watery solution without the employment of a filter, and after slightly rinsing with distilled water, to add it to the buttery matter for further analysis.

Analysis of the United Buttery and Last Oily Matters.—To these matters, after they have been dissolved in a sufficiency of hot alcohol, the lead process, as described in the paragraph relating to the ether extract of the white matter, may at once be applied. Kephalin lead and myelin lead are precipitated, lecithin, cholesterin, and some myelin lead remain solution, together with other matters to be described. Thus we have:—

Precipitated from and insoluble in boiling spirit.	Kephalin-lead (all).	
	Myelin-lead (part).	
Soluble in boiling spirit, part deposited on cooling.	Cholesterin	deposited on cooling.
	Myelin-lead and a cerebroside	deposited on cooling.
	Lecithin.	
	Cerebrol.	
	Yellow matter.	
	Kephalosterin and other matter.	

The kephalin-lead and myelin-lead are separated from each other by ether as above described, and their quantities weighed. The lead contained in the respective preparations is ascertained by a special quantation of the phosphorus and of the lead, and from these data the actual amount of each of the free phosphorised principles is calculated.

The myelin-lead and cholesterin deposited from the hot alcohol are also separated by ether, and the products weighed. The cholesterin may be weighed as residue from the ether solution after distillation of the ether from a tared flask, or it may be recrystallised from very dilute spirit, and weighed in the crystallised state. When thus recrystallised it is so pure that its melting point is mostly at 145°.

The cold spirit solution containing lecithin, cerebrol, yellow matter, kephalosterin, and mostly a residue of cholesterin, together with some lead acetate, has now to be chemolysed so that its ingredients can be ascertained from the products of decomposition. The spirit is first evaporated and the residue heated with water, which dissolves the acetate of lead and any impurity soluble in water. This purification with hot water (cold water has to be avoided, as it makes the residue swell, and present a semi-mucilaginous state) is repeated until the water is free from lead. The residue is now treated as follows:—

Chemolysis of the last Residue of the Buttery and last Oily Matter which was not precipitated by Lead Acetate.—The necessity for this process arises from the fact that the bulk of the lecithin cannot be

separated from the last traces of cholesterin and from the small quantities of ether (cerebrol or éléencephol) formed during the long processes with alcohol. There are, moreover, matters present, such as kephalosterin and others, which are all soluble in ether as well as alcohol, and do not combine with reagents in such a manner as to become insoluble while the other bodies remain soluble, or inversely.

The mixture as described is chemolysed in the same manner as the residual mixture from the lead-precipitates from the ether-extract of white matter described above. It is mixed with the necessary quantity of baryta hydrate and water, and heated in a closed platinum tube under pressure, at 125°, for at least six hours. It may also be boiled in an open platinum dish, with frequent renewal of the water, for at least 12 hours, but the process is liable not to be complete, as the fatty acid salts formed may enclose portions of lecithin and protect them from the influence of the baryta. Smaller quantities of matter may be enclosed in glass tubes, and sealed, and then heated to 125°, surrounded by water in a closed brass tube. This last precaution is necessitated by the fragility of the glass, if unprotected. The employment of the platinum tube is preferable owing to its simplicity. The contents of the tube are extracted with hot water, which removes excess of baryta, *glycerophosphate of barium and neurin*. These are isolated as above described, the glycerophosphate by alcohol, and the neurin by platinic chloride.

The remaining solid products of the chemolysis, which are insoluble in water, are extracted with boiling spirit. In this all cholesterin, kephalosterin, and other matters not yet fully identified, and a little barium salt of a fatty acid, dissolve, while the barium salt of the fatty acids produced by the chemolysis from lecithin and cerebrol remain insoluble.

The spirit solution, when sufficiently watery, deposits all cholesterin, which is dried and weighed; it retains in solution the kephalosterin and the other matters alluded to. This last mother-liquor is evaporated to dryness and weighed, and the product is entered into the record of the analysis as kephalosterin and other crystallisable undetermined products.

The barium-salts of the fatty acids, oleate and margarate or palmitate, are decomposed with hydrochloric acid and water under ether, and the liberated fatty acids are then combined, first with ammonia, next with lead. From the dry mixture of lead oleate and margarate the former is extracted by ether. The *margarate* remains as a white substance, which is easily weighed; the *oleate* is best weighed as residue of the ether solution distilled from a tared flask.

In calculating the amount of *lecithin* from the oleic and margaric acids obtained as lead-salts, and comparing these data with those obtained by calculation from the quantities of glycerophosphoric acid and neurin, the following circumstances have to be borne in mind.

Of the lecithin present in the brain, and extracted by the alcohol, a part is already decomposed during the chemical operation. We shall see below how an excellent *quantation of the lecithin* can be made upon any portion of brain, provided it is not intended to estimate many other or all the ingredients of the extract obtained therefrom. But in the course of a complete analysis of a single brain, such as is here described, the complete quantation of the lecithin as such is not feasible, on account of the decomposition just alluded to. This decomposition causes a loss of neurin and glycerophosphoric acid on the one hand, which remains in the watery mother-liquor containing the principles of the brain soluble in water, and a loss of fatty acids on the other, which combine with alcohol and form ethers (cerebrol, éléencephol). These ethers are of course again decomposed during the baryta chemolysis, so that ulti-

...ly the whole of the fatty acids which were present in the form of ...thin are obtained as barium salts. It follows, therefore, that when ... quantities of fatty acids found are compared with the quantities of ... urin and glycerophosphoric acid, equivalent for equivalent, there will ... *an excess of fatty acid* over the neurin and glycerophosphoric acid. ... is therefore necessary to take the fatty acids as the basis of calcula... for the amounts of lecithin present in the original extract, and the ... urin and glycerophosphoric acid only as subsidiary aids for the ... ermination of the minimum and the control against accident.

Separation of the Ingredients of the Buttery Matter by a Process in which Caustic Baryta is employed.—In this process baryta takes the ... ace of lead which is employed in the process just described. The ... sults are in the main analogous. The mother-liquors will have to be ... ecomposed with more baryta, as in the previous case, but the process ... ill not be delayed by the necessity of removing the excess of lead ... cetate.

The buttery matter is dissolved in a sufficient quantity of hot spirit ... nd filtered hot. To the hot solution, hot baryta water (saturated in ... e cold) is now added while the mixture is kept boiling. A precipitate ... eparates and becomes adhesive. *The solution* is decanted and filtered ... oiling. *The precipitate* which remains insoluble is exhausted with ... oiling spirit, dried and treated with ether. *Kephalin-barium* goes into ... olution, while a white salt (*myelin-barium* and small quantities of *barium salts of fatty acids*) remains insoluble. The hot spirit solution, ... cooling, deposits a white precipitate and then is almost free from ... gredients. The precipitate is isolated, dried, and exhausted with ether. ... his solution of ether contains all cholesterin, and a mere vestige of ... ephalin. The white precipitate contains, firstly, a body soluble in ... oiling spirit, and deposited from it in needles (curved needle body), ... nd a body which is now, after removal of the bodies soluble in ether, ... soluble in boiling spirit, and contains much barium and phosphorus.

The kephalin-barium as precipitated from human buttery by baryta ... ater in the above process is not yet a pure compound, as was shown ... y the following tests of a specimen. It was insoluble in boiling spirit, ... asily soluble in ether, twice precipitated by absolute alcohol and dried ... ver oil of vitriol at 70°.

Barium quantation: 0·6380, deflagrated with soda and nitre, &c., gave 0·2528 $BaSO_4$, equal to 23·30 % Ba.

Phosphorus quantation: The filtrate from the $BaSO_4$ was treated with magnesia mixture, &c., and gave 0·1066 pyrophosphate, equal to 4·67 % P.

The amount of barium found corresponds approximately to a di-barium kephalin, which requires 24·77 % Ba. But the amount of phosphorus is in excess of that theory, which requires 2·9 % P, and must be left unexplained. Dibarium-kephalin has an analogue in a diplumbic kephalin, which I have described in earlier researches.

Analysis of the Cerebrin Mixture.—This mixture, which was formerly believed to be an immediate principle and termed *protagon*, consists of a number of well-defined immediate principles, which belong mainly to three distinct categories.

(1.) *Cerebrosides* or bodies of the glucoside type, which contain as constitutional base a peculiar sugar, *cerebrose*. The type of these bodies, *phrenosin*, was first described in these researches; it forms the main quantity of the ingredients of the mixture. It is insoluble in cold absolute alcohol. *Kerasin* is soluble in much cold absolute alcohol, at least for some time, and is deposited slowly on standing in a semi-crystalline form. A body crystallising apparently in curved needles, to

be described in a future chapter, is permanently soluble in alcohol. These bodies do not combine with lead when it is added as acetate to their solution in spirit. But there are a number of cerebrosides which do combine with lead when it is added as acetate to their spirit solution: of this class is *cerebrinic acid*, and *spherocerebrin*, and the three bodies accompanying spherocerebrin as described in the article: "On the cerebrin substances which combine with metallic oxydes."

(2.) *Phosphorised bodies* of the glyceride type, which owing to the fatty acids contained in them being identical with or nearly allied to the fatty acids contained in the cerebrosides, have the same or very nearly the same solubility in alcohol and other solvents as the cerebrosides, and therefore follow them so pertinaciously as to have caused the belief in their being in a state of combination with them.

(3.) *Sulphurised bodies* of which a preliminary description has been given in a previous chapter.

The cerebrin-mixture also always contains varying quantities of bases, particularly potash and soda.

The cerebrosides being mostly neutral bodies, having no affinity for either acid or alkali, can be isolated with solvents only. Of the cerebrin-mixture an elementary analysis should be made, and its results stated in atoms with sulphur as unit, and again with phosphorus as unity. This will at once show the proportions of atoms to each other, and be the chief control of the processes of quantitative separation to be undertaken afterwards.

The cerebrin mixture, dissolved in alcohol, may then be treated with lead acetate and a little ammonia, and the precipitate may be exhausted with boiling spirit. This process separates the mixture of cerebrosides into the two categories described above under (1). The sulphurised bodies remain principally in the lead precipitate, the phosphorised principles distribute themselves over precipitate and solution. The separation and quantation of these matters I shall be able to describe fully in a future report.

The nitrogen in the cerebrosides is probably all present in a form, which by chemolysis with baryta or sulphuric acid, sufficiently long continued, will appear as sphingosin. Thus neurin on the one, and sphingosin on the other hand, will probably be the only nitrogenised nuclei to be isolated by chemolysis. They are certainly the principal ones as regards quantity; should the sulphurised bodies contain any nitrogen and that in a particular form, then the quantity of this particular product would be much below the quantities of the products just mentioned.

XII.—Quantation of Constituents of an entire Human Brain.

Of the *left hemisphere*, which when entire weighed 596 g, 460 g were taken for the following quantations. The tissue was comminuted and exhausted with boiling spirit, &c., and yielded the following educts:—

Albuminous matters = 35·06 g.

White matter, deposited from spirit, 21·93; the same after extraction with cold ether (cerebrin-mixture) dry = 12·28 g. Soluble in ether 9·65 g. These *cerebrosides*, &c. boiled with absolute alcohol, gave—

(*a.*) Less soluble cerebrins, phrenosin, &c. deposited immediately 8·11 g.

(*b.*) More soluble ones, kerasin, &c. deposited after days 0·56 g.

and left insoluble stearoconote, albumin, and paper fibres 0·78 g.

Of this last item 0·53 were soluble, 0·25 insoluble in hot benzol. The insoluble in benzol part contained a body which left a black ash on combustion, and contained much phosphorus. It was an earthy

compound of a phosphorised body. It gave a brownish red, but no genuine oleo-cholide *reaction.*

The alcoholic solution from the cerebrins = 340 c.c. was divided in two equal halves of 170 c.c. each. To one half platinic chloride was added as long as a precipitate was produced. The precipitate, containing a phosphorised body, weighed 0·85 g, and contained (Pt = 0·0817 g) = 9·58 % Pt.; it yielded further 0·0954 pyrophosphate of Mg. = 3·13 % P. To the second half of the alcohol solution cadmic chloride was added, and the precipitate obtained weighed 0·8124 g; it yielded 0·1232 g CdO, = 13·27 % Cd; and further 0·0995 pyrophosphate of Mg = 3·42 % P.

Of the matters dissolved in spirit, and not precipitated by these alkaloid reagents, 0·3619 g were yet precipitated by water.

The ether extract from the cerebrin mixture weighed 9·65 g.

The buttery matter, soluble entirely in cold ether = 21·65 g.

The last oily matter, treated with lead acetate, yielded lead precipitates which together weighed 11·8450 g.

Out of these there was obtained *lecithin* = 2·8995 g. (This was easily soluble in cold absolute alcohol, and gave the characteristic tests with platinic and cadmic chloride.)

Further *kephalin* lead = 0·8435 g = 0·5659 g *kephalin; and myelin* lead = 6·6080 g = 5·2041 *myelin.*

The last watery extract gave a phospho-molybdate precipitate of alkaloids, which weighed dry 3·7084 g. It yielded further 1·56 g. *zinc lactate* dried in vacuo over oil of vitriol = 1·0074 g. *pure sarcolactic acid.*

The inosite amounted to 2·5335 g.

The undefined organic extractives weighed 2·7822 g.

The salts, as carbonates, weighed 1·7218 g. Of these 0·39 were potassium = 0·745 KCl, and 0·39 sodium = 0·9844 NaCl. The salts as chlorides weighed 1·7294 g, and out of this mixture 2·4610 g $PtCl_4(KCl)_2$ were obtained.

In the calculation of kephalin, myelin, and lactic acid, the following formulæ were used, which should be considered as provisional, and will have to be tested by further, or supplemented by direct analysis of the products:—

Kephalin, molec. weight = 836; kephalin lead = $C_{42}H_{75}NPO_{13}Pb_2$ M.W. = 1246.

Myelin, M.W. = 760; myelin lead = $C_{40}H_{73}PbNPO_{10}$, M.W.=965.

Sarcolactic acid, $C_3H_6O_3$, M.W. = 90.

Zinc sarcolactate dihydrate $C_6H_{10}ZnO_6 + 2H_2O$, M.W. = 279.

The buttery matter which had been soluble in ether (21·6450 g) was boiled with baryta and yielded 6·7 g of cholesterin, with 16·5 g of barium salts of fatty acids. The latter contained oleate (as shown by the oleo-cholide reaction), much phosphorus, and a small quantity of a body which was soluble in ether. But the complete extraction with ether was impracticable, as the turbid liquid would neither settle nor allow itself to be filtered. This difficulty is not rarely met with when dry barium or lead salts of brain educts are subjected to ether treatment for the extraction of some ingredient.

The ether extract from the cerebrin mixture, containing the kephalin and cholesterin was treated with alcoholic lead acetate and filtered boiling. The insoluble residue of kephalin lead weighed 2·6410 g, which, assumed to contain 2Pb, is equal to 1·772 g free kephalin.

The solution in spirit of the cholesterin, &c. was evaporated, and the residue freed from lead acetate by hot water. The cholesterin was then re-crystallised and weighed. When the cholesterin thus obtained

was re-dissolved in ether, a white matter remained insoluble, weighing 0·2680 g and being entirely combustible on platinum foil.

Quantation of the Ingredients of the Right Hemisphere.

The total hemisphere, with the membranes, weighed 589 g.; after removal of membranes, 564 g.; of this quantity, 465 g. were employed in the following quantations:—

The albuminous substance amounted to 35·68 g, equal to 7·66 % of the hemisphere tissue.

The white matter deposited from spirit dry was = 18·60 g.

The ether extract from this = 6·97 g.

The cerebrins insoluble in ether = 11·63 g.

The buttery matter (= 21·66 g) in alcohol was treated with lead acetate, and boiled. The precipitates insoluble in boiling alcohol were suspended in ether for separation, but the cylinder containing the mixture breaking spontaneously, the quantation was lost. In the table this void is filled up by data obtained from the data concerning the left hemisphere by calculation.

The inosite was obtained in two portions, one with neutral acetate (it was not previously known that inosite was so precipitated), another with basic, together about 0·43 g. The lead having been removed from the liquid with sulphuric acid, the *lactic acid* was extracted and formed into zinc salt. It weighed, dry at 100°, 0·87 g. = 0·64 sarcolactic acid.

Alkaloids were precipitated from the mother-liquor by phosphomolybdic acid. The precipitate weighed 3·8 g, and contained 1·30 g mixed alkaloids.

The mother-liquor was treated with baryta, &c., evaporated, and the residue burnt. The *indefinite extractives* amounted to 2·63 g.

Of potassium 0·25 g, of *sodium* 0·40 g were obtained.

The hot mother-liquor of the buttery matter treated with lead acetate (of which operation the insoluble precipitates were lost as above described) on cooling deposited myelin lead and *cholesterin*, weighing, when dry, 6·99 g. The myelin weighed 5·22 g.

The spirit filtrate, containing *lecithin and little cholesterin*, after evaporation left a residue weighing 8·13 g.

The remaining bodies containing cholesterin were chemolysed with baryta, and gave *cholesterin* = 8·93 g pure, and 8·80 g *barium salts of fatty acids.*

Quantation of the Ingredients of the Cerebellum.

The total weight of the fresh cerebellum with membranes was 135 g, and after removal of membranes, &c. 124 g were analysed.

The albuminous matter amounted to 11·3809 g.

The white matter from first spirit was = 1·81 g. Of this 0·2185 g were soluble, 1·6645 g insoluble in ether = cerebrins.

The filtrate from the white matter was evaporated and treated directly with lead acetate. There were obtained kephalin lead = 1·97 g; myelin lead 1·65 g; in the solution cholesterin with lecithin and myelin lead = 3·26 g; a second portion of myelin lead with lead salt insoluble in ether containing *inosite* = 0·05 g. This inosite having been precipitated by neutral lead acetate (a reaction hitherto unknown) made the quantation of this body inaccurate. It amounted probably to 0·66 g for the entire cerebellum.

The lactate of zinc dry at 100° weighed 0·19, equal to 0·1352 g sarcolactic acid.

The alkaloids precipitated by phosphomolybdic acid weighed in combination 1·62 g, free 0·6920 g.

The extractives mixed with the salts weighed 1·55 g.

The alkali salts consisted of 0·01 *potassium* and 0·02 *sodium*.

The mixture of cholesterin, lecithin and myelin lead above described as weighing 3·26 g, was boiled with baryta and a little spirit for three hours. The watery solution of neurin, glycerophosphate and excess of barium was separated from the insoluble matter. The cholesterin was extracted by boiling spirit, and weighed 1·95 g. Its melting point was 145°. The *barium salts of the fatty acids* weighed 2·56 g.

Quantation of the Constituents of the Mesenkephalon.

The mesenkephalon and medulla oblongata weighed 34 g, without the membranes 33 g.

The albumen amounted to 2·48 g.

The white matter weighed 0·64 g.; of this 0·03 were soluble in ether, 0·56 insoluble.

The buttery matter yielded 0·67 kephalin lead.

The lactate of zinc weighed 0·11, air dry, equal to 0·07 *lactic acid.*

The rest of the matters soluble in water were not estimated on account of their small quantity.

The data thus far ascertained have been arranged in the following table. They claim to be minima only, and with improved processes somewhat larger quantities will probably be found. Blanks are left where the quantations could either not be made, or were unsatisfactory when the products were tested.

The experience gained by this analysis has shown that the division of all the educts of a brain into five primary categories is practical They are (1) albumen, (2) white matter, (3) buttery matter, (4) last oily matter, (5) matters soluble in water. Of these the last oily and the buttery matters may be treated together for the separation of their ingredients, when the cerebellum or mesenkephalon are concerned. When derived from the hemispheres these products are more conveniently kept apart.

The table contains about 130 data. But it will be seen that the cerebrosides, *e.g.* occupy only one column (col. 6). Whereas probably ten columns will be required to register the quantities of various specific bodies of which the insoluble in ether part of the white matter is composed. I estimate, therefore, that the quantitative analysis of one brain will involve the production and weighing of about three hundred definite bodies or compounds. Each of the four divisions of the brain, and each of the two varieties of tissue, the white and the grey, would thus require about fifty quantations for chemical characterisation.

The loss registered in the table appears at first sight enormous. One part was experienced by diffusion from the parts immersed in water for the estimation of the specific gravities as described in a previous chapter. This quantity was 1·65 g. as ascertained by evaporation of the water and weighing of the dry residue. An uncertain part of weight was lost by evaporation. But the greatest part was lost in the course of the anatomical separation of white and grey matter, in the course of comminution, and transfer from filter to filter and vessel to vessel. This loss may be much diminished by improved apparatus, but in the present case it imports only a slight degree of inaccuracy into the general result of the analysis, as its effect has been supplemented by a proportional calculation.

TABLE showing RESULTS of the QUANTITATIVE ANALYSIS of a HUMAN BRAIN.

Weights in grammes; third decimals below 5 omitted, above 5 added as 1 to second decimals. Membranes weighed 58 g.

	1. Weights with Membranes.	2. Weights without Membranes.	3. Quantities analysed.	4. Albumen.	5. White Matter.	6. W.M. insoluble in Ether.	7. W.M. soluble in Ether.	8. Buttery Matter.	9. Kephalin Total.	10. Myelin Total.	11. Lecithin Total.	12. Cholesterin Total.	13. Inosite.	14. Lactic Acid.	15. Hypoxanthin and Alkaloids.	16. Indefinite Extractives.	17. Potassium.	18. Sodium.
Right hemisphere	589	564	465	35·68	18·60	11·63	6·97	21·66	3·34	5·22	5·90	8·93	0·43	0·64	1·30	2·63	0·25	0·40
Left hemisphere	596	570	460	35·06	21·93	12·28	9·65	21·65	—	5·20	—	6·09	0·38	1·00	1·06	2·78	0·39	0·39
Cerebellum	135	129	124	10·94	1·88	1·66	0·22	3·26	1·29	3·76	2·97	1·95	0·05	0·13	0·67	1·49	0·01	0·02
Mesenkephalon and medulla oblongata.	34	33	33	2·48	0·64	0·56	0·03	—	0·45	0·23	0·41	1·01	0·06	0·07	—	0·73	0·01	0·03
White tissue	—	—	66	5·70	6·98	4·56	2·42	5·31	0·06	0·16	0·48	2·15	0·14	0·05	—	0·44	0·03	0·04
White tissue for quantation of water.	—	—	9·2	0·80	0·97	0·64	0·33	0·74	0·002	0·02	0·07	0·30	0·02	0·006	—	0·06	0·004	0·006
Grey tissue	—	—	46	3·50	0·30	—	0·30	—	0·15	0·02	0·73	0·90	0·69	0·04	0·10	0·31	0·01	0·09
Grey tissue for quantation of water.	—	—	6·2	0·46	0·04	—	0·04	—	0·02	0·003	0·09	0·12	0·09	0·006	0·01	0·04	0·001	0·01
Loss in operations	—	—	86·6	6·58	4·12	2·24	1·88	4·14	0·63	0·69	1·10	1·36	0·08	0·20	0·21	0·52	0·07	0·07
Totals	1354	1296	1296	101·20	55·46	33·57	21·84	50·76	5·94	15·30	11·75	24·21	1·94	2·14	3·35	9·00	0·78	1·00

LONDON:
Printed by GEORGE E. B. EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.

ELEVENTH ANNUAL REPORT

OF THE

LOCAL GOVERNMENT BOARD

1881–82.

SUPPLEMENT

CONTAINING

REPORT OF THE MEDICAL OFFICER

For 1881.

Presented to both Houses of Parliament by Command of Her Majesty.

LONDON:
PRINTED BY GEORGE E. B. EYRE AND WILLIAM SPOTTISWOODE.
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.
FOR HER MAJESTY'S STATIONERY OFFICE.

1882.

To avoid fine, this book should be returned on
or before the date last stamped below

1083-4-44

I241 Local Govt. bd. Ann. rep.
B1 Suppl. 104843
1881

NAME	DATE DUE